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A COMPARATIVE ANALYSIS OF ELECTRONIC CONTENT IN PUBLIC POST-HIGH SCHOOL TECHNICAL INSTITUTES AND ELECTRONICS TECHNOLOGY REQUIREMENTS OF INDUSTRY.

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THE PURPOSE OF THIS STUDY WAS TO ASCERTAIN THE EXTENT TO WHICH POST-HIGH SCHOOL TECHNICAL EDUCATION PROGRAMS, THROUGH ELECTRONICS CONTENT OFFERING, WERE MEETING INDUSTRY'S NEEDS IN ELECTRONICS TECHNOLOGY. A CHECKLIST OF 435 INSTRUCTIONAL UNITS OR ITEMS, PREPARED FROM AN ANALYSIS OF 31 ELECTRONICS BOOKS AND 13 MANUALS USED BY ELECTRONICS TEACHERS, WAS SENT TO 63 ELECTRONICS TEACHERS WHO WERE ASKED IF THEY TAUGHT THE VARIOUS CONTENT UNITS IN DEPTH, DISCUSSED THEM BRIEFLY, OR DID NOT TEACH THEM. IT WAS ALSO SENT TO 223 INDUSTRIAL FIRMS AND GOVERNMENTAL AGENCIES TO INDICATE IF THEY BELIEVED THE VARIOUS INSTRUCTIONAL ITEMS TO BE REQUIRED, PREFERRED, OR UNNECESSARY KNOWLEDGE FOR THE TECHNICIANS THEY EMPLOYED. AN ANALYSIS OF THE DATA REVEALED THAT ELECTRONICS INSTRUCTORS PLACED SIGNIFICANTLY MORE EMPHASIS ON BASIC ELECTRONICS CONTENT THAN INDUSTRIAL PERSONNEL INDICATED WAS NECESSARY. SPECIFICALLY, 89 INSTRUCTIONAL UNITS WERE INDUSTRIALLY REQUIRED AND TAUGHT IN DEPTH, AND 108 UNITS WERE DESIGNATED AS INDUSTRIALLY PREFERRED AND DISCUSSED BRIEFLY. THERE WERE NO MAJOR DIFFERENCES BETWEEN INDUSTRIAL AND EDUCATIONAL EMPHASIS IN THESE AREAS. HOWEVER, 227 INSTRUCTIONAL UNITS WERE INDUSTRIALLY PREFERRED BUT TAUGHT IN DEPTH, AND AN ADDITIONAL 11 UNITS WERE INDUSTRIALLY UNNECESSARY BUT DISCUSSED BRIEFLY. THERE WERE SIGNIFICANT DIFFERENCES BETWEEN INDUSTRIAL AND EDUCATIONAL EMPHASIS IN THESE AREAS. THESE FINDINGS SHOULD PROVIDE A SOUND BASIS FOR ADJUSTMENTS IN THE ELECTRONIC CURRICULUM AND RESULT IN UPDATED PROGRAMS ATTUNED TO INDUSTRIAL NEEDS. (HC)

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SUMMARY

Project No. 6-8590
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A COMPARATIVE ANALYSIS OF ELECTRONIC CONTENT IN PUBLIC POST-HIGH SCHOOL TECHNICAL INSTITUTES AND ELECTRONICS TECHNOLOGY REQUIREMENTS OF INDUSTRY

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Mississippi State University
State College, Mississippi

June 1967

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Performed Pursuant to a Grant with the
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Electronics has become an integral part of many phases of our technological society. In major industries many production and assembly lines have been electronically programmed. Information retrieval, data processing, and space travel are functions of the computer, and modern communications rely heavily on electronic advancements. Technical training institutes must provide technicians with an education which will keep them abreast of these developments. The quality and quantity of the resulting education should not be haphazard but rather should be a reflection of industry's needs. The technical institutes, whether they are a part of postsecondary area vocational-technical schools, community or junior colleges, or extensions of state universities, can meet these needs by cooperating with industries in a continuous reevaluation of their technical curriculums.

Purpose

The purpose of this investigation was to ascertain the extent to which post-high school technical programs, through electronic content offerings, were meeting industry's needs in electronics technology. This research was conducted in Region IV (U.S.Office of Education designation) which includes Alabama, Florida, Georgia, Mississippi, South Carolina, and Tennessee.

Procedure

A list of 397 firms and governmental agencies probably employing electronic technicians was compiled from information supplied by State Employment Security offices, state industrial directories, and electronics technology instructors. Of these 397 industrial firms and governmental agencies, 223 indicated they employed electronic technicians.

Electronic teachers were requested to provide lists of instructional materials they used in the presentation of electronic subject matter. Thirty-one books and 13 manuals were used by three or more instructors. An analysis of this material resulted in the development of a content checklist which was used as the major data-gathering instrument. After refinement by 10 jury members, the checklist contained 435 instructional units or items of electronic content.

The 63 electronic instructors to whom this checklist was mailed were asked to indicate whether they taught the various content units in depth, discussed them briefly, or

did not teach them. Returns of 92 percent were obtained from this group.

A similar instrument was sent to the 223 firms which had indicated the employment of electronic technicians. These firms were requested to indicate whether they believed the various instructional items were required, preferred, or unnecessary knowledge of the technicians they employed. Eighty-six percent of the forms sent to industry were returned. A total of 15,828 electronic technicians were employed by the 175 responding firms which supplied this employment data.

An analysis of the data was made by assigning relative values to the instructional units. This was done according to the distribution of responses to each of the 435 units in question.

Of the 435 units of content analyzed, 72.6 percent were taught in depth and 27.4 percent were discussed briefly. Industrially, 20.5 percent of the content was required knowledge, 77 percent was preferred knowledge, and 2.5 percent was considered unnecessary knowledge. There was educational and industrial agreement on the amount of emphasis placed on 45.3 percent of the electronic content. In the remaining 54.7 percent of the instructional units, educators placed more emphasis on content than industrial personnel believed necessary.

Conclusions and Recommendations

The total analysis revealed that electronic instructors placed significantly more emphasis on basic electronic content taught than industrial personnel indicated was necessary. Specifically, the following conclusions were reached:

1. Eighty-nine instructional units were placed in the category industrially required and taught in depth, and 108 content units were designated as industrially preferred and discussed briefly. In these instances, the hypothesis that no major differences existed between electronic course content offered in technical institutes and subject matter required of electronic technicians was accepted.

2. A total of 227 instructional units were represented in the category, industrially preferred but taught in depth. An additional 11 units of instruction were placed in the industrially unnecessary but discussed briefly category. Here, the hypothesis

was rejected because more educational emphasis was placed on content than industrial personnel indicated was necessary. Either the instructors were justified in over-emphasizing these units to compensate for lack of knowledge retention, or better utilization of additional time spent on these units should have been considered.

3. The positions which could be filled by electronic technicians covered the entire spectrum from routine jobs to those which required a high degree of specialization. Therefore, a customized approach to technical training ranging from one to three years would reduce the dropout rate, encourage more students to enter the technical field, and better meet the demands of industry whose technical needs range from the relatively simple to the most complex.

It is believed that these findings will provide a sound basis for adjustments in the electronic curriculums and result in updated programs attuned to industrial needs.

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CHAPTER I

INTRODUCTION

Electronics has become an integral part of many phases of our technological society. In major industries many production and assembly lines have been electronically programmed. Information retrieval, data processing, and space travel are functions of the computer, and modern communications rely heavily on electronic advancements. Technical training institutes must provide technicians with an education which will keep them abreast of these developments. The quality and quantity of the resulting education should not be haphazard but rather should be a reflection of industry's needs. The technical institutes, whether they are a part of postsecondary area vocational-technical schools, community or junior colleges, or extensions of state universities, can meet these needs by cooperating with industries in a continuous reevaluation of their technical curriculums.

Background of the Problem

Much emphasis has been placed on the need for technical personnel in industry during the past decade. The implementation of post-high school technical education programs was enhanced by the provisions of Title VIII of the 1958 National Defense Education Act (NDEA). This Title amended the Vocational Education Act of 1946 (The George Barden Act) by adding a new Title III, providing for technical education programs for young people and adults. Since the bill's enactment, much time and effort have been devoted to the development of electronics technology programs. This development gave rise to a need for an electronic content study of these programs to see how well they were meeting the requirements of industry.

Statement of the Problem

The purpose of this investigation was to ascertain the extent to which post-high school technical programs, through electronic content offerings, were meeting industry's needs in electronics technology. This study was designed to answer the following questions:

1. How much emphasis is being placed on the various instructional units of electronic course content

in technical programs in Region IV?[1]

2. What preemployment electronic subject matter content do industries consider to be required, preferred, or unnecessary knowledge for the electronic technicians they employ?

3. What similarities and differences exist between electronic course content taught in technical institutes and those required by personnel who work as electronic technicians in industry?

4. What are the implications of these findings in curriculum content improvement in existing and future electronics technology programs?

Significance of the Problem

There was lack of information available as to what electronic instructional units or items were being taught versus industry's interpretation of subject matter requirements.

Jelden[2] made an analysis of electrical content in textbooks and other instructional materials used in teacher education institutions. This research was conducted to ascertain what similarities and differences existed between electrical knowledge presented to industrial arts majors and requirements of personnel who worked with electronic devices in industry. He recommended that:

> An analytical study should be made of the offerings in electricity and electronics in various private or public technical schools, and these findings should be made available to industry for rating and appraisal.[3]

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[1] Form HEW-110 shows Region IV to include Alabama, Florida, Georgia, Mississippi, South Carolina, and Tennessee.

[2] David L. Jelden, "Electrical Information Content Included in Industrial Arts Education Vs. Knowledge Required of Electronic Technicians" (unpublished Doctor's dissertation, College of Education, University of Missouri, 1960).

[3] *Ibid.*, 130.

Technical education should be a reflection of our industrial society's needs. Therefore, curriculum development and revision must be founded on the cooperative effort of educational and industrial personnel working together to interpret industry's preemployment educational requirements. During a recent White House Conference on Education, participants agreed that:

> . . . even now there is ample evidence of the failure of schools to provide youth with the skills that industry needs. A major reason according to several panelists, has been the lack of cooperation and communication between industry and educators in planning school curriculums. As the labor market becomes increasingly complicated, it will be more and more important to bring industries and unions to join in curricula planning and in altering programs as needs for skills change.[4]

The significance of this research was that it provided direction to those who wished to maintain a quality electronics technology program. This study also enabled the electronics instructor to better use valuable time for upgrading the program rather than attempting to interpret the needs of industry.

Hypothesis

The hypothesis to be tested was that no major differences existed between electronic course content offered in technical institutes and subject matter required of electronic technicians.

Assumptions

An assumption was made that the persons responding to the information forms understood the questions and that their responses represented valid answers.

Limitations

This research included two-year public post-high school institutes offering electronics technology curriculums qualifying under NDEA Title VIII funds in Region IV. Firms in this area employing electronic technicians

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[4] Theodore Schuchat, "From Washington," School Shop, XXV (September, 1965), 86, 90.

(Dictionary of Occupational Titles Code Number 0-67.110 - new Code Number 003.181) were also included. The survey was conducted on a regional basis so it would be broad enough to have general applicability but still be characteristic of individual institutional needs within the southeast region.

The necessity for developing course content to fit the needs of a particular area was indicated by the authors of a national electronics technology curriculum guide when they stated that its contents:

> . . . should not be taken literally and imposed upon a community but rather be used as a guide in developing a curriculum which is best suited for a given situation and one which will meet the national defense needs for occupations in this field of work.[5]

Obviously a two-year program cannot cover in depth all the instructional units or items which are pertinent to the various specialized areas of electronics technology. Therefore, the instructional units or items included were limited to electronic content necessary for the understanding of electronic phenomena up to the point of specialization. The content analyzed was found in textbooks and laboratory manuals used by more than two electronic instructors from the responding schools.

Definitions

The following terms were defined as to their usage in this investigation:

Basic Electronics. Electronic content above the basic electricity level and up to the point of specialization.

Electronic Technician. One who applies electronic theory, principles of electrical circuits, electrical testing procedures, engineering mathematics, and related subjects. This knowledge is used to lay-out, test, troubleshoot, repair, and modify developmental and production electronic equipment. The work of the electronic technician is usually performed under the direction of an electrical engineer.

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[5] Electronic Technology, A Suggested 2-Year Post-High School Curriculum, U.S.Department of Health, Education, and Welfare (Washington: U.S.Government Printing Office, 1960), 8.

Instructional Unit or Item. A small facet of an instructional area which appears rather consistently in technical electronic text material and can be taught in a relatively short time.

Technical Institutes. An NDEA-supported, two-year public post-high school that offers training designed to place the graduate in a specific job or a cluster of jobs immediately upon graduation and with a minimum of on-the-job training.

Outline of Procedure

The steps followed during the process of this research were as follows:

I. Pertinent information including doctoral dissertations, curriculum guides, technical education books, periodicals, and reports were reviewed.

II. Information Form I requesting the names and addresses of electronic instructors was developed and mailed to state supervisors of technical education. Form I also requested information about the availability of state-developed electronic curriculum guides and about the expected number of electronics technology programs to be added in 1967.

III. Information Form II requesting the names of educational materials used in the presentation of electronic course content was developed and sent to electronic instructors. This form also requested the names of past, present, and/or probable employers of electronic technicians.

IV. State Employment Security personnel were asked to provide the names and addresses of firms employing electronic technicians. Names of additional organizations probably employing technicians were obtained from state industrial directories and from electronics technology instructors.

V. Information Form III, asking for the names of persons cognizant of the technicians' basic electronic knowledge requirements, was sent to the various industries. This form also requested the number of electronic technicians employed by these firms.

VI. Checklist Information Form IV was developed as a result of an analysis of instructional materials used by three or more electronics technology programs.

VII. A jury of qualified electronic instructors was selected to evaluate and refine Information Form IV.

VIII. Forms IV and V were sent to electronic instructors and industrial electronic personnel, respectively. These were the major data-gathering instruments.

  A. Form IV requested electronic instructors to indicate the degree of emphasis they placed on various units or items of electronic content.

  B. Form V asked technical supervisors to indicate the amount of emphasis they believed necessary to be placed on various units or items of electronic content.

IX. A comparative analysis of content taught in post-high school technical institutes versus technical electronic requirements of industry was made. Finite values of two, one, and zero were assigned to the Required, Preferred, and Unnecessary columns, respectively. These respective values were multiplied by the number of responses in the Required, Preferred, and Unnecessary columns of each instructional unit or item. The relative value of each instructional unit was then determined by obtaining the sum of the products and dividing by the total number of responses to the unit in question. The three columns were assigned the following relative value ranges: Required, 1.50-2.0; Preferred, 0.50-1.49; Unnecessary, 0.00-0.49. This same procedure was used to determine the relative values of the instructional units or items checked by electronic instructors and industrial personnel. The resulting data were tabulated in four separate tables as follows:

  A. Industrially Required and Taught in Depth (desired).

  B. Industrially Preferred but Taught in Depth.

C. Industrially Preferred and Discussed Briefly (desired).

D. Industrially Unnecessary but Discussed Briefly.

X. Final reports were prepared and submitted to Texas A&M University and to the U.S. Office of Education, the funding agency.

Communicable results of the findings in tabular form were sent to state and local administrators and instructors of electronics technology programs, to Employment Security Commission Offices, and to selected industries requesting this information. It is believed that these findings will provide a sound basis for adjustments in the electronic curriculums and result in updated programs attuned to industrial needs.

CHAPTER II

DEVELOPMENT, DISTRIBUTION, AND COLLECTION OF INFORMATION FORMS

The majority of the data were obtained through state employment security commission offices and industrial directories in Region IV and through five information forms distributed in the same geographical area. This area, as designated by the U.S.Department of Health, Education and Welfare, includes Alabama, Florida, Georgia, Mississippi, South Carolina, and Tennessee.

Information Form I

Names and addresses of state level technical education supervisors were obtained. These individuals were sent a letter along with Information Form I entitled State Level Information on Instruction and Materials.

Information Form I content. The supervisors were asked to provide information pertaining to electronics technology programs within their respective states. Among the information requested were the following:

1. The names and addresses of instructors responsible for electronic instruction in technical institutes.
2. The number of new electronics technology programs expected to be added in 1966-67 and 1967-68.
3. Information as to whether some agency within the state had developed a post-high school electronics technology curriculum guide.

Information Form I analysis. Seventy-three technical institutes operated electronics technology programs. Table 1 shows the distribution of existing and expected new programs in each of the six states. No consistant relationship between the number of existing and expected programs was evident.

Replies to Form I indicated that Mississippi, South Carolina, and Tennessee had developed post-high school electronic technology curriculum guides while Georgia had plans for developing a guide during 1966-67. These curriculum guides were developed for the purpose of improving instruction in the electronics area. It was stated in the Mississippi guide that the instructor should make a

TABLE 1

ELECTRONICS TECHNOLOGY PROGRAMS IN REGION IV

State	Existing Programs (1965-66)	New Programs Expected 1966-67	New Programs Expected 1967-68
Alabama	17	8	0
Florida	15	0	0
Georgia	21	3	1
Mississippi	9	1	1
South Carolina	9	2	1
Tennessee	2	0	0
Totals	73	14	3

> . . . careful examination of this publication and continued reference to it while teaching. Lesson plans for lectures and demonstrations as well as laboratory experiments should be made using this publication as a guide. This will attest to realistic evaluation of content, organization, and time allotment for each unit.[1]

Information Form II

An individual letter accompanied by an instruction sheet and Information Form II was sent to teachers in each of the 73 electronics technology programs.

Information Form II content. This form, entitled Educational Materials Used in Presentation of Electronic Course Content and Firms Hiring Electronic Technicians, asked for the following information:

1. The name and address of the instructor who completed the form.

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[1] A Guide for Use in Developing Training Programs in Electronics Technology, Curriculum Laboratory, Department of Industrial Education, Mississippi State University (State College, Mississippi, 1964), ix.

2. The title, author, and publisher of texts, laboratory manuals, workbooks, and/or major references, including state-developed curriculum guides, used in each electronics course. (All educational materials used by three or more instructors were to be analyzed.)

3. The names, addresses, and hiring personnel of at least two firms in the instructor's geographical area employing electronic technicians. (This information was requested to correlate this research more closely with the actual employers of the electronics technology graduates.)

4. An indication as to whether or not the instructor would participate further in this study.

Information Form II analysis. Electronic books and manuals used by three or more technical programs in the presentation of electronic content numbered 31 and 13, respectively. Most of the books and manuals were of recent origin with the majority having been published within the last four years. Only two instructors indicated that they used a state-developed electronics curriculum guide as a reference.

To better correlate this research with actual employers of electronic technicians educated in Region IV, the electronics technology instructors in this geographical area were asked to list two or more past, present, or potential employers of their educational product. After all duplications were eliminated, the number of probable employers of electronic technicians as obtained from electronic instructors totaled 113.

The 73 instructors receiving Form II were asked if they would continue to participate by filling out a forthcoming checklist indicating the amount of emphasis they placed on various instructional units of electronic content. A total of 68 teachers returned the form. Of this number 55 instructors stated that they would cooperate, eight gave no indication, three of the teachers said their programs had not yet been established, and two stated that they would not cooperate further in this project. This breakdown is given by states in Table 2. The overall response indicated a professional attitude toward curriculum improvement on the part of the electronics technology instructors.

TABLE 2

INDICATION OF FUTURE COOPERATION BY ELECTRONIC INSTRUCTORS IN REGION IV

State	Will Cooperate	No Indication	Program Not Established	Will Not Cooperate	No Return	State Totals
Alabama	9	1	3	1	3	17
Georgia	19	2	0	0	0	21
Florida	11	3	0	1	0	15
Mississippi	8	1	0	0	0	9
South Carolina	7	0	0	0	2	9
Tennessee	1	1	0	0	0	2
Totals	55	8	3	2	5	73

Firms Employing Electronic Technicians

An attempt was made to include all employers of electronic technicians in Region IV. To this end, a conference was held with Mississippi Employment Security personnel to determine how the names and addresses of these firms could be obtained. The group decided that all local Mississippi Employment Security offices would be asked to provide the following information:

1. Names of industrial firms and governmental agencies in their area employing electronic technicians and electronic mechanics. (The latter classification was included so that firms listing their electronic technicians with employment offices as mechanics would not be eliminated.)

2. Addresses of such firms.

3. Names of personnel officers or other hiring officials.

Satisfactory results were obtained through the above approach. Letters were sent to the directors of Employment Security Commissions in the other five states. They were asked to provide the type of information obtained from Mississippi.

In addition to Mississippi, only Alabama was able to provide the data requested. The other four states did not maintain a record of firms employing electronic technicians. Consequently, follow-up letters were written to the Employment Security Commissions in Florida, Georgia, South Carolina, and Tennessee. Each was asked to supply a copy of its state industrial directory. From these directories, probable employers of electronic technicians, as listed under the Standard Industrial Classification, Major Group 36 __ (Electrical and Electronic Machinery, Equipment and Supplies), were obtained.

In the final analysis 397 names of probable employers of electronic technicians were obtained from the following sources:

1. Electronic technology instructors.

2. Employment Security Commission offices.

3. State Industrial Directories.

Table 3 shows the number of probable employers obtained from each of these three sources within the various states.

TABLE 3

SOURCE OF PROBABLE EMPLOYERS

State	Source of Names			
	Instructors	Employment Security Offices	Industrial Directories	State Totals
Alabama	17	62	0	79
Florida	35	0	84	119
Georgia	39	0	38	77
Mississippi	8	49	0	57
South Carolina	12	0	17	29
Tennessee	2	0	34	36
Totals	113	111	173	397

Information Form III

This form, with an accompanying letter, was sent to the 397 probable employers of electronic technians. If the name of an individual within any of these firms was available, the letter was addressed to him. Otherwise, the letter was addressed to the personnel managers of industrial firms and to the civilian personnel officers of government installations. When this phase of the study was terminated, 87 percent or 344 of 397 responses had been received.

Information Form III content. Printed on a postal card and entitled Electronic Technician Employment Data, this form requested the following:

1. Information on whether the firm employed electronic technicians, and if so, how many. (To provide a common ground for understanding, the definition of an electronic technician as it pertained to this study was provided.)

2. The name of a person within the firm who was aware of the organization's educational requirements in the technical electronics area. (This person was later asked to fill out a checklist.)

Information Form III Analysis. Of the 344 responses to Form III, 223 firms indicated the employment of electronic technicians and 53 companies stated that they did not employ any such personnel. An additional 39 forms were duplications and 29 were returned unclaimed. Table 4 shows a statewide breakdown of responses to Information Form III.

The local offices of three of the larger firms indicated that information pertaining to the educational requirements of their technicians could best be obtained through regional offices. This accounted for 25 of the 39 duplications shown in Table 4.

Of the 223 forms returned by firms indicating the employment of electronic technicians, 129 listed the respondent as the person aware of his firm's educational requirements for electronic technicians. Each of the other 94 firms gave the name of some other individual as the person to be written. Table 5 shows this information according to states.

Information Forms IV and V

The purpose of the information obtained through these forms was to make a comparative analysis of electronic content taught in public post-high school technical institutes and knowledge requirements of electronic technicians. To develop these checklist forms, a thorough content analysis of the 31 electronic books and 13 laboratory manuals used by three or more electronic programs was made. First, the instructional units or items found in each of the books and manuals were recorded. Second, all duplications of content were eliminated. Third, the content was categorized into major divisions, subdivisions, and instructional units or items. The material was then inspected for content omissions, duplications, inconsistencies, and sequence by a curriculum specialist with an electronics background. Finally, this content was arranged into a tentative checklist form consisting of 11 major divisions, 54 subdivisions, and 427 instructional units or items.

Jury evaluation. Ten jury members were selected to evaluate and refine the tentative checklist. Five of these electronics instructors were selected as a result of personnel interviews held at the Mississippi junior colleges where they taught. The other jury members chosen taught in technical institutes in the other five states. The ten jury members selected had an average of 22.6 years experience in the electronics field.

TABLE 4

RESPONSES TO INFORMATION FORM III

State	Firms Employing Electronic Technicians	Firms Not Employing Technicians	Duplications of Firms	Returned Unclaimed	No Response Obtained	State Totals
Alabama	48	5	4	0	8	65
Florida	66	9	8	16	20	119
Georgia	35[a]	19	16	6	12	88
Mississippi	38	7	7	1	4	57
South Carolina	18	3	4	2	5	32
Tennessee	18	10	0	4	4	36
Totals	223	53	39	29	54	397

[a] Three of these firms were regional offices which supplied data about the electronic technicians they employed in all six of the states in Region IV.

TABLE 5

PERSONS AWARE OF ELECTRONIC TECHNICIANS' EDUCATIONAL REQUIREMENTS IN REGION IV

Person Aware of Educational Needs	State						Personnel Totals
	Ala.	Fla.	Ga.	Miss.	S.C.	Tenn.	
Form III Respondent	28	32	23	23	12	11	129
Other Individual	20	34	12	15	6	7	94
State Totals	48	66	35	38	18	18	223

The revised Information Form IV, entitled Basic Electronic Knowledge Requirements of Electronic Technicians (Educational), contained column headings labeled Taught in Depth, Discussed Briefly, and Not Taught (Appendix A). The form consisted of 12 major divisions, 54 subdivisions, and 435 instructional units or items.

The same content was used for Information Form V which was headed Basic Electronic Knowledge Requirements of Electronic Technicians (Industrial) and whose column headings were labeled Required Knowledge, Preferred Knowledge, and Unnecessary Knowledge (Appendix B).

Administration of Information Form IV. This educational content checklist was sent to the 55 electronics technology instructors who had agreed to participate and to the eight who gave no indication of intent to cooperate. A letter and an instruction sheet for filling out the form were also sent.

The instructors were asked to assist in the last phase of this investigation by doing the following:

1. Reading the instruction sheet.
2. Completing Information Form IV as it pertained to their program.

3. Returning the form at their earliest convenience.

The jury believed that Form IV probably contained sufficient electronic content for a three-year (rather than a two-year) curriculum if all the instructional units or items listed therein were taught in depth. With this in mind, each instructor was asked to mark the checklist as it pertained to his existing program according to the following criteria:

1. Taught in Depth--Instructional units or items that the instructor thought should be thoroughly understood by his students.
2. Discussed Briefly--Information which the instructor believed not extremely important or worth only brief discussion because of a limiting time factor.
3. Not Taught--Instructional units that were mentioned only as interest items, were of little significance, or were so specialized that there was no room for them in the basic electronic curriculum.

Sequence of presentation was not a major concern since individual preference in this respect varies. The instructors were asked to be objective in their judgments, for the purpose of this project was not to evaluate any one program but to analyze the total educational and industrial situation as it pertained to electronic technicians. They were requested to check all items and to indicate their years of experience in electronics.

When this phase of the research was terminated, 92 percent, or 58 of the 63 teachers had responded. The distribution of responses is shown in Table 6.

The instructors were asked to indicate their years of experience in electronics. To the extent that this criteria could be used as an indicator of their qualification to fill out the checklist, it was met without reservation. The instructors had a mean average of 23.5 years experience in electronics. This included an average of 6.8 years teaching, 9.1 years industrial, 5.6 years military, and 2.0 years of other experiences in the electronics field.

Administration of Information Form V. This checklist entitled Basic Electronic Knowledge Requirements of Electronic Technicians (Industrial), was sent to the 223 industrial firms and governmental agencies which had indicated the employment of electronic technicians.

TABLE 6

DISPOSITION OF FORM IV BY INSTRUCTORS

State	Forms Sent	Forms Returned	
		Number	Percent
Alabama	10	8	80
Florida	14	13	93
Georgia	21	20	95
Mississippi	9	9	100
South Carolina	7	6	86
Tennessee	2	2	100
Totals	63	58	92

The checklist was accompanied by an instruction sheet and by one of two letters. One letter was addressed to the respondents of Information Form III who said they were aware of their firm's educational requirements for the electronic technicians they employed. The other letter was addressed to personnel whom the respondents indicated were aware of their firm's needs.

These individuals were asked to assist by doing the following:

1. Reading the instruction sheet.
2. Completing Information Form V as it pertained to education requirements of electronic technicians within their respective firms.
3. Returning the form at their earliest convenience.

As was the case when Information Form III was sent to industry, the definition of an electronic technician was again given to provide a common basis for understanding. Personnel receiving Form V were made aware of the comprehensiveness of this checklist and of the limited period of time within which this content had to be presented. They were told that with this time limitation in mind, they should mark the checklist as it pertained to their technicians' educational needs according to the following criteria:

1. Required Knowledge--Instructional units or items of which their technicians must have a working knowledge to perform their duties.

2. Preferred Knowledge--Information not absolutely essential but with which their technicians should have some familiarity.

3. Unnecessary Knowledge--Instructional units or items that have little or no bearing on the job responsibilities of their technicians.

The industrial personnel were asked to check (✓) all items and to indicate their years of experience in electronics.

Of the 223 forms sent to industry, 191 or 86 percent were returned. Seven of these forms were not completed in sufficient detail and, therefore, were omitted from the analysis. The distribution of responses by industrial personnel is shown in Table 7.

TABLE 7

DISPOSITION OF FORM V BY INDUSTRIAL PERSONNEL

State	Forms Sent	Forms Returned		
		Number	Percent	Usable
Alabama	48	40	83	38
Florida	66	51	77	49
Georgia	35	32	91	31
Mississippi	38	34	89	32
South Carolina	18	18	100	18
Tennessee	18	16	89	16
Totals	223	191	86	184

Of the 184 usable forms returned by industrial personnel, 175 indicated the size of their technical electronics staff. The total number of electronic technicians employed by the 175 firms was 15,828, and the range of employment was from 1 to 5,463. Table 8 shows the number of electronic technicians employed within the various states.

TABLE 8

ELECTRONIC TECHNICIANS EMPLOYED WITHIN VARIOUS RANGES IN EACH STATE

State	Range 1-10 (No. firms)	Number Technicians Employed	Range 11-100 (No. firms)	Number Technicians Employed	Range 101-1000 (No. firms)	Number Technicians Employed	Range Over 1000 (No. firms)	Number Technicians Employed	Total Firms	Total Employed
Alabama	16	91	17	696	3	675	0	0	36	1,462
Florida	17	115	21	800	8	2,500	0	0	46	3,415
Georgia	14	88	8	196	5[a]	2,154	2[b]	6,983	29	9,421
Mississippi	25	120	4	145	2	305	0	0	31	570
South Carolina	5	22	12	377	0	0	0	0	17	399
Tennessee	9	41	6	170	1	350	0	0	16	561
Totals	86	477	68	2,384	19	5,984	2	6,983	175	15,828

[a] This number includes one of the regional firms that employs electronic technicians throughout Region IV.

[b] This number represents two of the firms that employ electronic technicians throughout Region IV.

As was the case with the instructors, the industrial personnel were asked to indicate their years of experience in electronics. They had a mean average of 17 years experience. This included an average of 11.2 years electronic experience in industry, 1.1 years in teaching, 2.4 years of military experience, and 2.3 years in other electronic endeavors.

CHAPTER III

ANALYSIS OF DATA

The data obtained through Information Forms IV and V were analyzed to ascertain the extent to which technical electronic programs were meeting industry's needs. The total analysis revealed that electronic instructors placed significantly more emphasis on basic electronic content than industrial personnel indicated was necessary for beginning technicians.

Analysis Procedure

Forms IV and V each contained 435 basic units or items of electronic content. Electronic instructors were requested to indicate whether each of these items was taught in depth, discussed briefly, or not taught. Similarly, electronic supervisors were requested to indicate whether each of these 435 items was required, preferred, or unnecessary knowledge of their technicians.

The same analysis procedure was used on educational and industrial responses.

An example of the educational analysis follows:

> The total number of teachers responding to the instructional unit on Kirchhoff's laws was 58.
>
> The distribution of responses according to emphasis placed on this unit was as follows:
>
> | | |
> |---|---|
> | Taught in Depth | 55 |
> | Discussed Briefly | 3 |
> | Not Taught | 0 |
> | Total Responses | 58 |
>
> Finite values of two, one, and zero were assigned to the Taught in Depth, Discussed Briefly, and Not Taught columns, respectively. These values were multiplied by the number of responses in their respective columns. Thus:
>
> | | |
> |---|---|
> | Taught in Depth | 55 x 2 = 110 |
> | Discussed Briefly | 3 x 1 = 3 |
> | Not Taught | 0 x 0 = 0 |
>
> The relative value of the instructional unit was determined by obtaining the sum of the products and

dividing by the total number of responses. Therefore:

$$\begin{array}{r} 110 \\ 3 \\ \underline{0} \\ 113 \end{array} \div 58 = 1.95 \text{ (relative value).}$$

The three columns were assigned the following relative value ranges:

Taught in Depth	1.50 - 2.00
Discussed Briefly	0.50 - 1.49
Not Taught	0.00 - 0.49

The educational relative value for Kirchhoff's laws was 1.95. Therefore, Kirchhoff's laws fell in the Taught in Depth range.

A similar industrial analysis was made on Kirchhoff's laws and was found to have a relative value of 1.65. Therefore, this instructional unit was categorized as Required Knowledge. Consequently, Kirchhoff's laws was placed in a table entitled Electronic Content Industrially Required and Taught in Depth. The same procedure was used on all 435 instructional units or items in Forms IV and V. To further indicate the amount of emphasis placed on each instructional unit educationally and industrially, the distribution of responses was converted to percentages.

Electronic Content Analysis

As a result of the content analysis, the instructional units were placed in four tables entitled:

Industrially Required and Taught in Depth.
Industrially Preferred but Taught in Depth.
Industrially Preferred and Discussed Briefly.
Industrially Unnecessary but Discussed Briefly.

This procedure was used so a comparison between industrial need and educational emphasis could readily be made.

Industrially required and taught in depth. Eighty-nine instructional units were placed in this category. These were the units which both industrial and educational personnel believed were very important concepts and which should be mastered by electronic technicians. The implications were that those instructors who did not place major emphasis on these instructional units should have considered doing so. The only major content divisions which were not represented in this category were microwave electronics and industrial electronics. This analysis is represented in Table 9.

Industrially preferred but taught in depth. A total of 227 or 52.2 percent of the instructional units were represented in this category. Two tenable conclusions were drawn from this portion of the analysis. Either the instructors were justified in over-emphasizing these units to compensate for lack of knowledge retention, or better utilization of the additional time spent on these units should have been considered. All 12 of the major divisions were represented in this phase of the analysis which is itemized in Table 10.

Industrially preferred and discussed briefly. Approximately one-fourth of the electronic content analyzed was represented in this category. The emphasis placed on this content indicated a desired balance between what was taught and industrially needed. Of the 12 major content divisions, only the one labeled inductance and capacitance was not represented. The 108 content units in this category are shown in Table 11.

Industrially unnecessary but discussed briefly. This category contains only 11 instructional units. These units are included under the major content divisions of test equipment, advanced circuits and systems, and microwave electronics. They are listed in Table 12.

Electronic Content Analysis Tables

In seven instances industry indicated that slightly more emphasis should be placed on individual units of instructional content than educators were presently doing. These included troubleshooting D-C circuits, ohmmeters, wattmeters, stroboscopes, hall generators, printed circuits, and microcircuits. However, in no instance was the difference great enough to place the industrial need in a higher relative value category than its educational counterpart. Educators placed as much as or more emphasis on the other 428 instructional units than industry indicated was necessary.

TABLE 9

ELECTRONIC CONTENT
INDUSTRIALLY REQUIRED AND TAUGHT IN DEPTH

Instructional Units or Items	Industrial Percentages			Relative Value[a]	Educational Percentages			Relative Value[b]
	Required Knowledge	Preferred Knowledge	Unnecessary Knowledge		Taught in Depth	Discussed Briefly	Not Taught	
DIRECT CURRENT								
Basic Principles								
electrical resistance, voltage, and current	98	2	0	1.98	98	2	0	1.98

---

[a] Finite values of two, one, and zero were assigned to the Required, Preferred, and Unnecessary columns, respectively. These respective values were multiplied by the number of responses in the Required, Preferred, and Unnecessary columns of each instructional unit or item. The relative value of each instructional unit was then determined by obtaining the sum of the products and dividing by the total number of responses to the unit in question. The three columns were assigned the following relative value ranges: Required, 1.50-2.0; Preferred, 0.50-1.49; Unnecessary, 0.00-0.49. This method for determining relative values was utilized in Tables 9 through 12.

[b] The above procedure was used to determine these relative values.

TABLE 9--Continued

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	a	b	c	d	e	f	g	h
batteries	66	24	10	1.56	62	38	0	1.62
magnetic fundamentals	77	21	2	1.76	90	10	0	1.90
series, parallel, and combination circuit theory	96	4	0	1.96	98	2	0	1.98
D-C circuit applications	91	8	1	1.90	97	3	0	1.97
troubleshooting D-C circuits	95	4	1	1.94	84	12	4	1.81
electro-capacitance	76	18	6	1.70	89	11	0	1.89
Network Laws (A-C and/or D-C)								
Ohm's law	98	2	0	1.98	98	2	0	1.98
Kirchhoff's laws	68	30	2	1.65	95	5	0	1.95
power formulas	77	18	5	1.72	100	0	0	2.00
ALTERNATING CURRENT								
Basic Principles								
electromagnetism	81	18	1	1.81	97	3	0	1.97
magnitude of induced voltage	74	22	4	1.70	93	7	0	1.93
sine waves	86	12	2	1.84	98	2	0	1.98
electromotive force	78	19	3	1.75	95	5	0	1.95
Vectors and Phase Relationship								
phase relationships	58	34	8	1.51	97	3	0	1.97
Transformers								
theory	87	12	1	1.86	97	3	0	1.97
turns ratio	80	18	2	1.78	98	2	0	1.98
impedance matching	73	24	3	1.69	98	2	0	1.98
types and applications (general)	76	20	4	1.72	72	28	0	1.72

TABLE 9--Continued

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	a	b	c	d	e	f	g	h
TEST EQUIPMENT								
Meter and Generator Usage								
basic meter movements	80	17	3	1.78	95	5	0	1.95
VTVM	89	7	4	1.85	97	3	0	1.97
multimeters	96	4	0	1.96	98	2	0	1.98
ohmmeters	97	3	0	1.97	93	7	0	1.93
oscilloscope	91	9	0	1.91	97	3	0	1.97
tube testers	66	27	7	1.59	61	39	0	1.61
transistor analyzers	64	34	2	1.62	66	34	0	1.66
capacitor tester	61	31	8	1.54	55	45	0	1.55
sine-wave generator	65	21	14	1.51	90	10	0	1.90
signal generator	70	18	12	1.59	90	10	0	1.90
INDUCTANCE AND CAPACITANCE								
Inductance								
self-inductance	78	21	1	1.77	95	5	0	1.95
mutual inductance	76	22	2	1.74	95	5	0	1.95
series and parallel	82	17	1	1.81	100	0	0	2.00
L-R circuits and time constants	72	24	4	1.69	95	5	0	1.95
inductive reactance	81	17	2	1.79	100	0	0	2.00
effects of varying current properties	59	34	7	1.52	95	5	0	1.95
frequency response	59	32	9	1.50	91	9	0	1.91
Capacitance								
theory of operation	90	9	1	1.89	100	0	0	2.00

TABLE 9--Continued

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	a	b	c	d	e	f	g	h
capacitor types and rating	83	14	3	1.80	90	10	0	1.90
effects in D-C circuits	87	11	2	1.86	98	2	0	1.98
R-C circuits and time constants	84	15	1	1.82	98	2	0	1.98
capacitive reactance	85	14	1	1.84	100	0	0	2.00
effects of varying circuit properties	60	36	4	1.57	97	3	0	1.97
bypass capacitor effect	71	25	4	1.67	98	2	0	1.98
R-L-C Circuits								
series R-L-C circuits	66	32	2	1.64	100	0	0	2.00
parallel R-L-C circuits	65	32	3	1.64	100	0	0	2.00
VACUUM TUBES								
Diodes								
rectification, detection	69	25	6	1.62	95	5	0	1.95
Triodes								
biasing methods, positive and negative	64	28	8	1.57	97	3	0	1.97
voltage amplification	59	33	8	1.51	100	0	0	2.00
SEMICONDUCTORS								
Semiconductor Diodes								
color code	72	26	2	1.71	74	24	2	1.72
PN junctions	70	27	3	1.68	100	0	0	2.00
forward and reverse bias	83	16	1	1.79	100	0	0	2.00
zener diodes	76	21	3	1.73	83	17	0	1.83

TABLE 9--Continued

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	a	b	c	d	e	f	g	h
silicon controlled rectifiers and switches	69	27	4	1.65	74	26	0	1.74
TRANSISTORS								
Construction and Characteristics								
junction type transistors	64	30	6	1.57	93	7	0	1.93
gain	73	22	5	1.69	100	0	0	2.00
transistor biasing	76	21	3	1.73	100	0	0	2.00
physical circuit operation (NPN and PNP)	85	12	3	1.82	100	0	0	2.00
Special Purpose Transistors								
power transistors	64	28	8	1.57	77	23	0	1.77
BASIC CIRCUITS AND SYSTEMS								
Power Supplies								
methods of rectification	89	10	1	1.88	98	2	0	1.98
types of rectifier circuits	84	15	1	1.83	98	2	0	1.98
principles of filtering	85	14	1	1.84	98	2	0	1.98
voltage dividers and doublers	80	19	1	1.79	98	2	0	1.98
voltage-regulator circuits	82	17	1	1.81	95	5	0	1.95
power supply troubles	83	16	1	1.82	88	12	0	1.88
Amplifier Fundamentals								
classes of operation	70	26	4	1.65	100	0	0	2.00
decibels	60	32	8	1.52	89	11	0	1.89
D-C amplifier gain	64	32	4	1.59	90	10	0	1.90

TABLE 9--Continued

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	a	b	c	d	e	f	g	h
A-C amplifier gain	66	29	5	1.61	97	3	0	1.97
frequency response	66	29	5	1.61	95	5	0	1.95
Basic Vacuum Tube Amplifiers and Circuits								
cathode follower	65	25	10	1.55	93	7	0	1.93
push-pull amplifier	61	30	9	1.52	98	2	0	1.98
amplifier coupling	60	30	10	1.50	98	2	0	1.98
TRANSISTOR CIRCUITS								
Transistor Amplifier Fundamentals								
reading transistor specifications	62	30	8	1.53	86	12	2	1.84
classes of operation	65	28	7	1.58	96	4	0	1.96
current, voltage, and power gain	74	21	5	1.68	97	3	0	1.97
base, emitter phase relationships	72	23	5	1.66	95	5	0	1.95
input and output resistance	65	29	6	1.59	100	0	0	2.00
transistor measurements	69	24	7	1.62	93	7	0	1.93
troubleshooting procedures	80	14	6	1.73	86	9	5	1.81
Transistor Amplifiers and Circuits								
common emitter, collector and base configurations	82	12	6	1.76	100	0	0	2.00
push-pull amplifiers	66	27	7	1.58	97	3	0	1.97
power amplifiers	62	31	7	1.55	100	0	0	2.00
D-C amplifiers	58	33	9	1.50	82	18	0	1.82
transistor circuit regulators	61	29	10	1.51	72	26	2	1.71
transistor voltage regulators	63	27	10	1.53	69	31	0	1.69
bias circuits	70	21	9	1.60	97	3	0	1.97

TABLE 9--Continued

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	a	b	c	d	e	f	g	h
printed circuits	68	24	8	1.61	50	50	0	1.50
ADVANCED CIRCUITS AND SYSTEMS								
Pulse and Switching Circuits								
diode and triode switching circuits	63	28	9	1.55	94	4	2	1.92
free running multivibrators	63	24	13	1.50	100	0	0	2.00

TABLE 10

ELECTRONIC CONTENT
INDUSTRIALLY PREFERRED BUT TAUGHT IN DEPTH

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	Required Knowledge	Preferred Knowledge	Unnecessary Knowledge	Relative Value	Taught in Depth	Discussed Briefly	Not Taught	Relative Value
DIRECT CURRENT								
Network Laws (A-C and/or D-C)								
Thevenin's theorem	22	43	35	0.88	68	30	2	1.67
maximum-power transfer theorem	38	35	27	1.09	80	16	4	1.77
ALTERNATING CURRENT								
Vectors and Phase Relationship								
vectors and vector diagrams	36	49	15	1.21	97	3	0	1.97
instantaneous values	46	44	10	1.35	95	5	0	1.95
complex numbers (J numbers)	18	47	35	0.83	78	19	3	1.74
polar vectors	17	46	37	0.80	80	16	4	1.77
Transformers								
transformer losses and ratios	49	43	8	1.40	84	16	0	1.84
delta and wye	42	41	17	1.25	52	48	0	1.52
frequency response	53	38	9	1.44	78	22	0	1.78

TABLE 10--Continued

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	a	b	c	d	e	f	g	h
TEST EQUIPMENT								
Meter and Generator Usage								
impedance bridge	54	33	13	1.41	61	35	4	1.58
frequency meter	56	24	20	1.37	55	41	4	1.52
pulse generator	59	26	15	1.43	75	23	2	1.74
square wave generator	64	20	16	1.48	83	17	0	1.83
INDUCTANCE AND CAPACITANCE								
Inductance								
Lenz's law	51	34	15	1.36	93	7	0	1.93
lag angle	52	38	10	1.42	98	2	0	1.98
instantaneous current analysis	34	44	22	1.13	86	14	0	1.86
a-f and r-f chokes	56	31	13	1.43	88	12	0	1.88
Q of a coil	52	36	12	1.40	90	10	0	1.90
high-frequency coils	47	36	17	1.30	76	24	0	1.76
low-frequency coils	48	35	17	1.31	76	24	0	1.76
Capacitance								
lead angle	52	41	7	1.45	98	2	0	1.98
Parallel, Series Resonant Circuits								
resonant circuit "Q"	47	39	14	1.33	95	5	0	1.95
analysis of series and parallel resonant circuits	45	35	20	1.25	98	2	0	1.98
applications of resonant circuits	48	37	15	1.32	100	0	0	2.00
resonant circuit bandwith	43	35	22	1.21	95	5	0	1.95
resonance curves	37	39	24	1.13	98	2	0	1.98
resonant filters	35	44	21	1.14	91	9	0	1.91

TABLE 10--Continued

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	a	b	c	d	e	f	g	h
VACUUM TUBES								
Fundamentals								
emitter materials	22	46	32	0.90	67	33	0	1.67
types of envelopes and bases	32	44	24	1.09	53	45	2	1.52
types of emission	43	38	19	1.25	83	17	0	1.83
cathodes; directly and indirectly heated	51	39	10	1.41	88	12	0	1.88
filaments, methods of heating	54	35	11	1.43	84	16	0	1.84
Diodes								
characteristic curves	47	42	11	1.36	90	10	0	1.90
Triodes								
load lines	31	55	14	1.17	95	5	0	1.95
saturation	40	49	11	1.30	95	5	0	1.95
interelectrode capacitance	35	46	19	1.16	93	7	0	1.93
transconductance, plate resistance	38	42	20	1.18	95	5	0	1.95
static and dynamic characteristic curves	32	49	19	1.13	91	9	0	1.91
transfer curves	22	51	27	0.95	86	14	0	1.86
amplification factor	53	37	10	1.43	100	0	0	2.00
equivalent circuits	33	50	17	1.16	86	12	2	1.84
Tetrodes								
interelectrode capacitance	35	43	22	1.14	90	8	2	1.88
effect of screen grid	45	40	15	1.30	90	10	0	1.90
effects of secondary emission	38	44	18	1.21	86	14	0	1.86
plate and screen characteristic curves	34	48	18	1.16	82	18	0	1.82

TABLE 10--Continued

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	a	b	c	d	e	f	g	h
Pentodes								
effect of suppressor grid	43	38	19	1.24	87	13	0	1.87
plate and dynamic characteristic curves	34	43	23	1.11	84	16	0	1.84
tube parameters	36	37	27	1.08	81	19	0	1.81
sharp and remote cutoff characteristics	36	43	21	1.15	84	16	0	1.84
Multigrid Tubes								
frequency conversion	32	40	28	1.04	95	5	0	1.95
pentagrid converters	30	38	32	0.99	88	12	0	1.88
pentagrid mixers	31	39	30	1.00	86	14	0	1.86
beam power tubes	36	39	25	1.10	84	16	0	1.84
multisection tubes	31	40	29	1.03	70	30	0	1.70
Special Application Tubes								
gas-filled regulators	50	36	14	1.36	86	14	0	1.86
thyratron tubes	47	32	21	1.26	90	10	0	1.90
photo tubes	34	40	26	1.04	54	46	0	1.54
cathode-ray tubes	48	39	13	1.35	91	9	0	1.91
high-frequency tubes	30	34	36	0.94	53	47	0	1.53
klystrons	26	28	46	0.80	69	31	0	1.69
SEMICONDUCTORS								
Fundamentals								
early development and use	30	50	20	1.10	53	45	2	1.52
atomic structure	28	47	25	1.02	91	9	0	1.91
crystal structure	29	47	24	1.04	88	12	0	1.88

TABLE 10--Continued

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	a	b	c	d	e	f	g	h
bonds	27	50	23	1.04	84	16	0	1.84
impurities	29	47	24	1.05	91	9	0	1.91
classification	49	39	12	1.38	90	10	0	1.90
electrons and hole charges	45	41	14	1.31	96	4	0	1.96
Semiconductor Diodes								
characteristic curves	56	37	7	1.49	95	5	0	1.95
point-contact diodes	52	39	9	1.43	74	24	2	1.72
tunnel diodes	48	42	10	1.38	69	31	0	1.69
TRANSISTORS								
Construction and Characteristics								
point contact transistor	51	36	13	1.38	66	31	3	1.62
static characteristic curves	49	39	12	1.38	95	5	0	1.95
dynamic transfer curves	45	41	14	1.31	93	7	0	1.93
load lines	50	38	12	1.28	95	5	0	1.95
graphical analysis	23	42	35	0.88	74	26	0	1.74
thermal properties	49	38	13	1.36	77	21	2	1.76
operating point	49	41	10	1.39	90	10	0	1.90
transistor noise	37	48	15	1.22	63	37	0	1.63
hybrid parameters	20	44	36	0.84	70	30	0	1.70
Special Purpose Transistors								
unijunction transistors	48	37	15	1.34	55	45	0	1.55
BASIC CIRCUITS AND SYSTEMS								
Power Supplies								

TABLE 10--Continued

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	a	b	c	d	e	f	g	h
polyphase power supplies	47	37	16	1.32	62	33	5	1.57
r-f power supplies	47	31	22	1.25	66	34	0	1.66
Basic Vacuum Tube Amplifiers and Circuits								
a-f amplifiers	59	30	11	1.48	98	2	0	1.98
paraphase amplifiers	28	44	28	0.99	84	16	0	1.84
i-f amplifier	53	28	19	1.34	98	2	0	1.98
audio amplifier circuits	45	32	23	1.22	69	29	2	1.67
audio-output stage	52	27	21	1.31	93	7	0	1.93
tone control circuits	34	34	32	1.01	54	46	0	1.54
bandpass amplifier circuits	45	30	25	1.20	83	17	0	1.83
attenuators	54	28	18	1.37	67	31	2	1.66
delayed action circuits	32	44	24	1.09	63	32	5	1.58
coupling	54	33	13	1.40	98	2	0	1.98
mixing circuits	48	29	23	1.24	84	14	2	1.83
Loudspeakers								
dynamic speakers	35	29	36	0.99	64	33	3	1.60
p-m speakers	39	27	34	1.00	75	21	4	1.72
Microphones and Pickups								
crystal	34	28	38	0.95	58	40	2	1.56
dynamic	36	28	36	1.00	59	38	3	1.55
Oscillators								
feedback-degeneration and regeneration	55	33	12	1.42	100	0	0	2.00
phase-shift oscillators	44	39	17	1.28	93	7	0	1.93
tuned plate-grid oscillators	47	31	22	1.25	86	14	0	1.86

TABLE 10--Continued

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	a	b	c	d	e	f	g	h
Hartley oscillators	50	35	15	1.35	95	5	0	1.95
Colpitts oscillators	50	34	16	1.34	91	9	0	1.91
Armstrong oscillators	42	39	19	1.23	90	10	0	1.90
electron-coupled oscillators	42	38	20	1.22	88	12	0	1.88
Pierce oscillators	40	33	27	1.12	79	21	0	1.79
crystal overtone oscillators	38	34	28	1.11	57	41	2	1.55
R-F Amplifiers and Circuits								
r-f amplifier circuits (general)	54	22	24	1.30	97	3	0	1.97
r-f power amplifiers	47	24	29	1.18	88	12	0	1.88
wide-band amplifiers	44	30	26	1.19	85	15	0	1.85
single and double tuned circuits	41	27	32	1.09	85	15	0	1.85
neutralizing circuits	34	32	34	0.99	84	16	0	1.84
r-f buffer and frequency multiplying	39	25	36	1.03	90	10	0	1.90
troubleshooting procedures	56	24	20	1.37	86	10	4	1.82
Transmitter Fundamentals								
c-w transmitter keying	21	30	49	0.72	58	33	9	1.50
classification of wave emission	30	25	45	0.85	67	30	3	1.64
parasitics and harmonics	36	24	40	0.97	80	17	3	1.76
percentage of modulation	37	24	39	0.98	88	10	2	1.86
plate and grid modulation	37	22	41	0.96	88	10	2	1.86
power distribution in a-m wave	29	25	46	0.83	73	24	3	1.69
transmitter measurements	35	24	41	0.95	75	23	2	1.73
a-m, f-m comparisons	33	27	40	0.94	76	24	0	1.76
transmitter alignment	35	25	40	0.94	74	22	4	1.70

TABLE 10--Continued

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	a	b	c	d	e	f	g	h
Radio Transmitters and Circuits								
c-w transmitters	24	28	48	0.77	66	29	5	1.60
a-m transmitters and circuits	32	26	42	0.88	83	17	0	1.83
f-m (reactance-tube) transmitters	26	27	47	0.79	82	18	0	1.82
f-m (phase) transmitters	27	26	47	0.81	64	31	5	1.59
troubleshooting procedures	38	21	41	0.97	78	15	7	1.71
Transmission of Radio Waves								
principles of radiation	39	31	30	1.09	84	14	2	1.82
radio-wave propagation	32	34	34	0.98	83	15	2	1.81
antenna fundamentals	37	29	34	1.03	88	10	2	1.86
transmission line theory	36	25	39	0.97	86	12	2	1.84
types of antennas	32	27	41	0.92	75	23	2	1.74
Radio Receiver Fundamentals								
reading schematic diagrams	62	20	18	1.44	93	5	2	1.91
hetrodyning principles	49	19	32	1.17	96	2	2	1.95
a-m detection	49	18	33	1.17	96	2	2	1.95
f-m detection	48	18	34	1.15	96	2	2	1.95
alignment procedures	46	20	34	1.12	92	5	3	1.88
troubleshooting procedures	49	21	30	1.20	83	10	7	1.75
Radio Receivers and Circuits								
superhet. receivers (general)	45	18	37	1.08	95	3	2	1.93
am-fm receivers	42	19	39	1.00	77	21	2	1.75
sideband receivers	32	26	42	0.89	53	45	2	1.52
AVC circuits	41	20	39	1.02	93	7	0	1.93
the B+ supply	51	20	29	1.22	93	5	2	1.91
squelch circuits	35	24	41	0.95	65	31	4	1.61

TABLE 10--Continued

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	a	b	c	d	e	f	g	h
limiters	40	24	36	1.04	84	14	2	1.82
discriminators	41	27	32	1.09	88	10	2	1.86
TRANSISTOR CIRCUITS								
Transistor Amplifier Fundamentals								
volume and tone controls	40	32	28	1.12	58	40	2	1.57
effects of feedback	58	32	10	1.48	90	10	0	1.90
equivalent circuits	46	40	14	1.31	85	15	0	1.85
Transistor Amplifiers and Circuits								
cascade audio amplifiers	53	25	22	1.32	95	5	0	1.95
R-C coupled audio amplifiers	54	26	20	1.34	100	0	0	2.00
direct-coupled amplifiers	57	31	12	1.45	91	9	0	1.91
tuned amplifiers	51	27	22	1.29	86	11	3	1.83
low-frequency amplifiers	58	27	15	1.44	85	15	0	1.85
high-frequency amplifiers	55	27	18	1.37	86	14	0	1.86
r-f and a-f amplifiers	46	28	26	1.21	88	12	0	1.88
wide band amplifiers	46	35	19	1.27	81	19	0	1.81
preamplifiers	47	37	16	1.31	73	23	4	1.70
phase inverters	54	31	15	1.38	82	18	0	1.82
stabilized circuits	55	35	10	1.45	91	9	0	1.91
Transistor Receivers								
power supplies	52	22	26	1.27	84	9	7	1.78
oscillators	50	22	28	1.22	88	10	2	1.86
modulation, mixing and detection circuits	44	25	31	1.13	79	19	2	1.78
agc circuits	41	27	32	1.09	80	17	3	1.76

TABLE 10--Continued

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	a	b	c	d	e	f	g	h
ADVANCED CIRCUITS AND SYSTEMS								
Nonsinusoidal Waveshapes								
square waves	56	31	13	1.44	98	2	0	1.98
rectangular waves	50	34	16	1.34	96	4	0	1.96
sawtooth waves	50	34	16	1.34	95	5	0	1.95
triangular and peaked waves	39	38	23	1.22	91	9	0	1.91
multi-segmented waves	26	40	34	0.92	59	34	7	1.52
curved wave forms	30	40	30	1.00	63	30	7	1.56
transients	46	37	17	1.30	81	19	0	1.81
D-C components of wave forms	42	38	20	1.23	88	12	0	1.88
A-C components of wave forms	43	38	19	1.24	88	12	0	1.88
wave form generation	38	43	19	1.18	87	13	0	1.87
Pulse and Switching Circuits								
bistable multivibrators	63	23	14	1.49	96	4	0	1.96
monostable multivibrators	62	23	15	1.48	96	4	0	1.96
astable multivibrators	52	28	20	1.31	95	5	0	1.95
blocking oscillators	46	34	20	1.28	96	2	2	1.95
shock-excited oscillators	35	31	34	0.99	89	9	2	1.88
gas-tube relaxation oscillators	29	37	34	0.94	80	18	2	1.78
gating circuits	61	24	15	1.46	88	10	2	1.86
delay circuits	57	28	15	1.42	84	14	2	1.82
pulse generators	54	28	18	1.37	79	19	2	1.77
triggering circuits	60	25	15	1.46	91	7	2	1.89
pulse counters	59	25	16	1.43	88	12	0	1.88
logic circuits	54	26	20	1.34	88	12	0	1.88
pulse amplifiers	55	28	17	1.38	82	18	0	1.82

TABLE 10--Continued

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	a	b	c	d	e	f	g	h
linear wave shaping	35	38	27	1.08	82	16	2	1.80
binary systems	51	27	22	1.28	81	17	2	1.79
decimal systems	48	32	20	1.27	77	16	7	1.70
Limiters, Clampers, Counters								
diode limiters	50	32	18	1.31	95	5	0	1.95
triode limiters	41	33	26	1.15	93	7	0	1.93
diode clamping	51	29	20	1.32	95	5	0	1.95
counters (frequency divider)	45	32	23	1.23	91	4	5	1.86
diode clippers	49	32	19	1.29	95	5	0	1.95
Sweep-Generator Circuits								
sawtooth-wave form circuits	37	39	24	1.14	94	6	0	1.94
gas-tube sweep generator circuits	26	32	42	0.85	73	23	4	1.70
vacuum-tube sweep-generator circuits	31	31	38	0.94	88	10	2	1.86
transistor sweep-generator circuits	33	36	31	1.02	68	28	4	1.65
sweep expansion and delay circuits	25	37	38	0.87	61	36	3	1.57
TV Transmitters and Receivers								
standard interlaced scanning	18	22	60	0.59	61	30	9	1.52
composite TV picture signal	20	21	59	0.61	64	25	11	1.54
TV receiver functional analysis	16	24	60	0.57	60	31	9	1.50
MICROWAVE ELECTRONICS								
Microwave Transmission								
generating microwave signals	26	24	50	0.76	72	16	12	1.60

TABLE 10--Continued

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	a	b	c	d	e	f	g	h
cavity resonators	24	23	53	0.72	72	17	11	1.61
waveguides	25	23	52	0.73	70	21	9	1.61
transmission lines	29	24	47	0.82	70	23	7	1.62
wavelength measurement	26	24	50	0.77	61	30	9	1.53
Special Amplifiers								
grounded-grid amplifiers	29	24	47	0.82	77	16	7	1.70
video amplifiers	31	21	48	0.83	74	21	5	1.68
D-C amplifiers	35	26	39	0.96	76	19	5	1.71
INDUSTRIAL ELECTRONICS								
Generators and Motors (Types and Theory)								
A-C and D-C generators	47	39	14	1.33	71	27	2	1.70
A-C and D-C motors	52	36	12	1.40	72	26	2	1.71
single-phase principles	52	34	14	1.38	72	26	2	1.71
three-phase principles	48	36	16	1.31	70	26	4	1.67
Synchros and Control Systems								
synchro applications	34	32	34	1.00	76	19	5	1.71
synchro principles	35	31	34	1.02	78	17	5	1.72
differential synchro	29	34	37	0.91	76	15	9	1.67
synchro control transformer	28	33	39	0.89	72	19	9	1.64
geared synchro systems	25	33	42	0.83	62	26	12	1.50
synchro connections	27	31	42	0.85	64	25	11	1.54
Servo Control Devices and Systems								
fundamental servo principles	40	29	31	1.10	72	23	5	1.66
common servomechanism systems	37	30	33	1.03	64	26	10	1.53

TABLE 10--Continued

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	a	b	c	d	e	f	g	h
Industrial Electronic Applications and Devices								
simple electronic circuits	61	21	18	1.44	70	25	5	1.65
transducers	42	32	26	1.15	57	36	7	1.50
thermistors	50	32	18	1.31	59	36	5	1.53
thyratron controls	33	34	33	1.00	66	24	10	1.55

TABLE 11

ELECTRONIC CONTENT
INDUSTRIALLY PREFERRED AND DISCUSSED BRIEFLY

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	Required Knowledge	Preferred Knowledge	Unnecessary Knowledge	Relative Value	Taught in Depth	Discussed Briefly	Not Taught	Relative Value
DIRECT CURRENT								
Network Laws (A-C and/or D-C)								
Norton's theorem	16	41	43	0.73	57	34	9	1.48
Millman's theorem	12	40	48	0.64	23	37	40	0.82
the superposition theorem	16	41	43	0.73	58	26	16	1.42
ALTERNATING CURRENT								
Transformers								
three-phase	47	31	22	1.25	45	53	2	1.43
TEST EQUIPMENT								
Meter and Generator Usage								
wavemeters	40	36	24	1.17	37	58	5	1.32
A-C bridge	47	39	14	1.27	47	50	3	1.43
thermocouple meter	49	36	15	1.34	41	54	5	1.36
wattmeter	58	30	12	1.47	41	59	0	1.41

TABLE 11--Continued

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	a	b	c	d	e	f	g	h
Ω meter	36	39	25	1.11	36	57	7	1.29
sweep frequency generator	51	24	25	1.27	51	44	5	1.46
linearity generator	19	38	43	0.76	13	53	34	0.78
stroboscope	34	38	28	1.07	7	60	33	0.74
VACUUM TUBES								
Fundamentals								
early development and use	28	46	26	1.02	45	48	7	1.39
Special Application Tubes								
subminiature tubes	30	47	23	1.07	43	54	3	1.40
ignitrons	20	41	39	0.80	38	57	5	1.33
photo-multiplier tubes	23	42	35	0.88	38	60	2	1.36
electron-ray indicators	26	38	36	0.91	40	60	0	1.40
SEMICONDUCTORS								
Semiconductor Diodes								
variable-capacitance diodes	34	50	16	1.19	44	47	9	1.34
photo diodes and photo transistors	34	47	19	1.13	45	48	7	1.38
hall generators	12	49	39	0.73	7	56	37	0.70
TRANSISTORS								
Construction and Characteristics								
transistor fabrications	27	47	26	1.02	50	41	9	1.41
Special Purpose Transistors								
tetrode transistors	22	50	28	0.94	35	61	4	1.32
photosensitive transistors	28	46	26	1.02	41	59	0	1.41

TABLE 11--Continued

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	a	b	c	d	e	f	g	h
field-effect transistors	36	47	17	1.19	45	55	0	1.45
thyristors	29	45	26	1.02	27	57	16	1.11
microcircuits	31	48	21	1.11	22	61	17	1.05
BASIC CIRCUITS AND SYSTEMS								
Amplifier Fundamentals								
stereophonic sound	18	28	54	0.64	33	60	7	0.91
Loudspeakers								
headsets	34	33	33	1.02	47	46	7	1.40
electrostatic speakers	22	32	46	0.76	40	51	9	1.31
speaker enclosures	14	28	58	0.56	19	59	22	0.97
Microphones and Pickups								
carbon	33	28	39	0.94	48	48	4	1.45
capacitor	28	28	44	0.84	41	57	2	1.39
velocity	26	26	48	0.77	42	49	9	1.33
ceramic	28	32	40	0.89	47	47	6	1.42
Radio Transmitters and Circuits								
v-h-f transmitters	33	21	46	0.87	53	40	7	1.46
u-h-f transmitters	30	23	47	0.84	46	46	8	1.37
sideband transmitters	27	26	47	0.80	52	45	3	1.48
Transmission of Radio Waves								
FCC regulations	19	39	42	0.77	34	54	12	1.21
Radio Receivers and Circuits								
T-R-F receivers	28	26	46	0.81	46	47	7	1.39
special receiver circuits	24	32	44	0.81	53	40	7	1.46

TABLE 11--Continued

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	a	b	c	d	e	f	g	h
TRANSISTOR CIRCUITS								
Transistor Amplifiers and Circuits								
reflex amplifiers	30	39	31	0.98	49	39	12	1.37
magnetic amplifiers	31	48	21	1.10	37	56	7	1.30
bridge arrangements	46	37	17	1.30	55	40	5	1.49
symmetry circuits	37	38	25	1.13	53	44	3	1.49
ADVANCED CIRCUITS AND SYSTEMS								
Pulse and Switching Circuits								
saturable-core reactor circuits	40	34	26	1.14	52	43	5	1.46
null detectors	45	31	24	1.21	48	42	10	1.38
Digital Computer Fundamentals								
computer applications	27	33	40	0.86	64	18	18	1.46
computer programming	19	32	49	0.70	26	43	31	0.94
computer math	23	32	45	0.77	57	29	14	1.43
adders and subtractors	25	30	45	0.80	59	29	12	1.46
methods of data storage	26	31	43	0.83	56	30	14	1.41
analog-to-digital conversion	31	28	41	0.91	37	37	26	1.11
TV transmitters and Receivers								
frequency bands	19	22	59	0.60	54	33	13	1.42
TV image and image resolution	14	23	63	0.51	44	45	11	1.33
MICROWAVE ELECTRONICS								
Microwave Transmission								
communications transmitters	21	26	53	0.68	57	32	11	1.46

TABLE 11--Continued

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	a	b	c	d	e	f	g	h
radar transmitters	20	23	57	0.63	46	44	10	1.35
duplexers	22	25	53	0.69	60	27	13	1.47
microwave antennas	25	25	50	0.75	54	37	9	1.45
Special Amplifiers								
traveling-wave amplifiers	18	27	55	0.64	34	54	12	1.21
parametric amplifiers	12	30	58	0.54	26	49	25	1.02
Miscellaneous (microwave)								
microwave mixers	17	28	55	0.63	54	29	17	1.36
Microwave Receivers								
communications receiver	22	27	51	0.72	48	39	13	1.36
radar receiver	18	22	60	0.57	39	46	15	1.25
Multiplexing								
time-division multiplexing principles	19	25	56	0.64	30	49	21	1.09
time-division multiplex transmitter and receiver analysis	16	25	59	0.57	21	54	25	0.96
frequency division multiplexing principles	18	27	55	0.63	23	55	22	1.02
frequency-division multiplex transmitter and receiver analysis	16	23	61	0.56	21	54	25	0.96
Microwave Measurements								
attenuation measurements	29	27	44	0.83	54	31	15	1.38
power measurements	30	21	49	0.81	60	26	14	1.36
reflectometer measurements	22	24	54	0.68	45	35	20	1.25
frequency measurements	30	22	48	0.82	60	24	16	1.44

TABLE 11--*Continued*

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	a	b	c	d	e	f	g	h
phase-shift requirements	20	24	56	0.76	38	45	17	1.21
measurement of Q	18	27	55	0.63	36	43	21	1.18
noise measurements	23	30	47	0.75	36	41	23	1.18
dielectric measurements	16	24	60	0.57	27	49	24	1.04
impedance measurement	23	24	53	0.70	46	36	18	1.28
directional couplers	25	23	52	0.74	51	33	16	1.35
absorption wavemeter	26	23	51	0.74	52	32	16	1.36
WSWR measurements	30	21	49	0.80	56	30	14	1.42
coaxial-cable measurements	27	23	50	0.77	52	30	18	1.34
propagation patterns	17	32	51	0.66	34	47	19	1.16
Radar System Principles								
block diagram analysis	23	22	55	0.66	55	29	16	1.38
CRT types	18	24	58	0.60	52	34	14	1.38
radar sweep chains	17	19	64	0.54	44	42	14	1.30
rank-mark generator chains	17	18	65	0.52	45	41	14	1.31
delay devices in radar systems	16	19	65	0.51	44	42	14	1.30
radar modulators	16	20	64	0.52	44	46	10	1.35
magnetrons	16	20	64	0.52	55	38	7	1.28
INDUSTRIAL ELECTRONICS								
Generators and Motors (Types and Theory)								
converters, inverters and dynamotors	38	41	21	1.16	47	50	3	1.43
speed regulators	38	34	28	1.10	47	39	14	1.33
generator and motor maintenance	42	36	22	1.19	37	44	19	1.18

TABLE 11--Continued

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	a	b	c	d	e	f	g	h
automatic motor controls	38	36	26	1.12	59	29	12	1.46
Synchros and Control Systems								
synchro capacitors	22	35	43	0.78	58	30	12	1.46
Servo Control Devices and Systems								
servomechanism chains	28	34	38	0.90	53	32	15	1.37
frequency response of servo systems	18	40	42	0.78	43	36	21	1.21
Industrial Electronic Applications and Devices								
decision or intelligence devices	23	32	45	0.79	28	45	27	1.02
electronic control systems	44	31	25	1.19	59	30	11	1.48
ultrasonics	12	31	57	0.56	31	53	16	1.16
electronic heating and welding	14	28	58	0.56	31	50	19	1.12
temperature recorders	39	30	31	1.08	34	52	14	1.21
varistors	41	34	25	1.16	54	35	11	1.44
time-delay relays	53	29	18	1.36	53	40	7	1.46
large-current polyphase rectifiers	15	35	50	0.66	38	38	24	1.14
high-frequency wavelengths	17	34	49	0.68	46	34	20	1.27
high-speed light and register controls	12	29	59	0.53	24	43	33	0.91
electronic timer circuits	45	29	26	1.20	59	31	10	1.48
radiation inspection and detection	15	25	60	0.56	24	47	29	0.95
photoelectric devices	33	38	29	1.03	41	47	12	1.29

TABLE 12

ELECTRONIC CONTENT
INDUSTRIALLY UNNECESSARY BUT DISCUSSED BRIEFLY

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	Required Knowledge	Preferred Knowledge	Unnecessary Knowledge	Relative Value	Taught in Depth	Discussed Briefly	Not Taught	Relative Value
TEST EQUIPMENT								
Meters and Generator Usage								
color-bar generator	12	22	66	0.47	11	55	34	0.77
ADVANCED CIRCUITS AND SYSTEMS								
TV Transmitters and Receivers								
camera tubes	13	23	64	0.48	44	44	12	1.31
TV transmitter functional analysis	13	22	65	0.48	34	55	11	1.45
MICROWAVE ELECTRONICS								
Special Amplifiers								
masers	5	26	69	0.36	5	69	26	0.79
lasers	5	29	66	0.39	11	58	31	0.80

TABLE 12--Continued

Instructional Units or Items	Industrial Percentages				Educational Percentages			
	a	b	c	d	e	f	g	h
Miscellaneous (microwave)								
backward wave oscillators	8	24	68	0.41	21	54	25	0.96
using Smith chart	13	21	66	0.48	29	46	25	1.04
Navigational Electronics								
sonar	8	20	72	0.35	22	45	33	0.89
loop antennas	13	23	64	0.49	29	51	20	1.09
radio detection finders	9	24	67	0.43	28	52	20	1.07
loran	6	22	72	0.34	18	43	39	0.59

Major Content Division Analysis

The 435 instructional units or items were categorized into 12 major content divisions. In each instance, the educational relative value was higher than the industrial value. Educators placed 10 major divisions into the Taught in Depth category and two into the Discussed Briefly range. Industrially, one major division was classified as Required Knowledge while 11 were in the Preferred Knowledge range. Industry and education both placed the greatest emphasis on inductance and capacitance and the least amount of emphasis on microwave electronics and industrial electronics. (See Table 13.)

TABLE 13

RELATIVE VALUE OF MAJOR CONTENT DIVISIONS

Major Content Divisions	Relative Value			
	Required Knowledge	Preferred Knowledge	Taught in Depth	Discussed Briefly
Direct Current		1.49	1.75	
Alternating Current		1.48	1.85	
Test Equipment		1.44	1.55	
Inductance and Capacitance	1.52		1.94	
Vacuum Tubes		1.16	1.79	
Semiconductors		1.33	1.72	
Transistors		1.30	1.68	
Basic Circuits and Systems		1.14	1.77	
Transistor Circuits		1.40	1.80	
Advanced Circuits		1.10	1.72	
Microwave Electronics		0.64		1.28
Industrial Electronics		1.01		1.43

Reactions by Industrial and Educational Personnel

During this investigation, various comments and opinions about electronic requirements were expressed by the educational and industrial participants. These comments, which were received through letters, personal interviews, and telephone conversations, were synthesized to convey the mainstream of thought to which educators and industrial personnel adhered.

Information Forms IV and V. A few of the instructors believed that Form IV should have had an additional column heading between Taught in Depth and Discussed Briefly. The respondents to both Forms IV and V, however, thought that the checklists represented a thorough analysis of basic electronic content.

The absence of an excessive listing of additional instructional units in the two forms attested to their comprehensiveness. At the end of each of the 12 major divisions in the two checklists, space was allotted for the inclusion of additional instructional units or items. Only one such item was listed more than once as necessary knowledge by either educational or industrial personnel. Grid-dip meters was listed twice by teachers and once by technical supervisors.

Many of the teachers and technician supervisors indicated that they involved several people in marking the checklists. In one instance, Form IV was marked after a critical examination of the instrument by three instructors and 47 students. Four of the respondents from industry made duplicates of Form V and had 11 of their technical supervisory personnel mark the checklist. Each supervisor completed the form according to his department's function.

Industrial reactions. A minority of the technical supervisors expressed the need for electronic specialists. Although they marked the checklist to reflect the basic needs of their technicians, the tendency to emphasize educational requirements applicable to their product or service specialty was evident. Some of these respondents stated that the technicians they employed needed more depth in a particular specialty such as industrial electronic process control, digital circuits, telemetry, or microwave theory. Other industrial personnel believed that the electronics curriculum should either be changed or lengthened to provide for more depth in specialties such as instrumentation, bio-medical, or navigational communications. Electronic specialists in large business machine and computer industries suggested a new curriculum. They stated that their job requirements could best be met by technicians who had obtained a cross-disciplinary education in electromechanical technology.

As was indicated in the foregoing paragraphs, various industrial respondents expressed a need for specialized electronic training for their technicians. However, the consensus was that the post-high school institutes were doing a commendable job of providing their technical students with basic electronic knowledge. The majority of the industrial personnel interviewed stated that their firms specialized in a particular electronic service or product. Consequently, the companies themselves could best provide the technicians with the specific training needed for the development of a high level of proficiency in the product produced or service rendered.

Councilman alluded to the need for providing the technician with the basic fundamentals when he stated:

> It seems to me that there is something more basic involved than the broad field of specialization for a technician just coming out of a training school; it is that he have a good understanding of the fundamentals involved in electronics as of the time period when he graduates from the training school and that the fundamentals covered be basic enough that his knowledge will not become rapidly obsolete in our fast changing field of technology.
>
> If, in addition to the broad basic fundamentals, he has some training in analyzing cause and effect, with respect to the fundamentals, it will be most helpful.[1]

Industrialists indicated that the trend in electronics is toward solid state devices, transistorized circuits, and integrated chips. The electronic industry of the future will employ the use of highly sophisticated digital and computerized circuits. However, the consensus was that if the technician acquired the broad basic fundamentals in school, he could obtain the electronic specialty on the job.

Educational reactions. Technical instructors reported that one of the inadequacies of their programs resulted from insufficient guidance. The teachers believed that proper screening and selection of students would decrease the dropout rate and increase the quality and quantity of instruction which could be incorporated into the electronics curriculum.

---

[1] Letter from C. L. Councilman, Chief Engineer, Electronic Communications, Inc., St. Petersburg, Florida, March 7, 1967.

Another difficulty technical programs encountered resulted from insufficient time in a two-year curriculum to teach in depth many of the specialties required by industry. However, as was indicated by the analysis, the post-high schools were providing their students with a broader technical background than was required of beginning technicians.

The apparent lack of properly coordinated guidance activities coupled with the emphasis on a rigid two-year technical program has added to the acute shortage of technicians. The instructors reported that they could place twice as many electronic technicians as they graduated. The positions which could be filled by these technicians covered the entire spectrum from routine jobs to those that required a high degree of specialization. Therefore, it seemed logical that through the cooperative efforts of industrial craft committees, guidance personnel, and electronic instructors a continuous technical program ranging from one to three years could be developed. Instead of exposing every student to the same content in a two-year program, the student would be allowed to seek his own level of attainment. This customized approach to technical education would probably reduce the dropout rate, encourage more students to enter the technical field, and better meet the demands of industry whose technical needs range from the relatively simple to the most complex.

CHAPTER IV

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this investigation was to ascertain the extent to which post-high school technical programs, through electronic content offerings, were meeting industry's needs in electronics technology. These findings were utilized in the formulation of recommendations concerning needed subject matter content revision.

This research was conducted in Region IV which includes Alabama, Florida, Georgia, Mississippi, South Carolina, and Tennessee. Names and addresses of electronic instructors were obtained through state supervisors of technical education. The teachers were requested to provide a list of all instructional materials they used in the presentation of electronic content. Returns were obtained from 93 percent of the 73 electronic instructors in Region IV. Books and manuals used by three or more teachers numbered 31 and 13, respectively.

Names of firms employing electronic technicians were obtained through State Employment Security offices and through state industrial directories. Additional names of probable employers of technicians were obtained from electronics technology instructors. These three sources yielded a total of 397 probable industrial and governmental employers of electronic technicians. An information form, asking for the names of persons cognizant of the technician's basic electronic knowledge requirements, was sent to the various industries. This form also requested the number of electronic technicians employed by these firms. When this phase of the study was terminated, 87 percent or 344 of the 397 industries written had responded. A total of 223 firms indicated the employment of electronic technicians.

The 44 books and manuals used by electronic instructors were analyzed. This analysis resulted in the development of a content checklist which was used as the major data-gathering instrument. After refinement by 10 jury members, the checklist contained 435 instructional units or items of electronic content. The 63 electronic instructors to whom this form was mailed were asked to mark the instrument as it pertained to their program according to the following criteria:

1. Taught in Depth--Instructional units or items that the instructor thought should be thoroughly understood by his students.

2. Discussed Briefly--Information which the instructor believed not extremely important or worth only brief discussion because of a limiting time factor.

3. Not Taught--Instructional units that were mentioned only as interest items, were of little significance, or were so specialized that there was no room for them in the basic electronic curriculum.

The checklist was returned by 92 percent of the instructors.

A similar instrument was sent to the 223 industrial firms and governmental agencies which had indicated the employment of electronic technicians. They were asked to mark the checklist as it pertained to their technicians' educational needs according to the following criteria:

1. Required Knowledge--Instructional units or items of which their technicians must have a working knowledge to perform their duties.

2. Preferred Knowledge--Information not absolutely essential but with which their technicians should have some familiarity.

3. Unnecessary Knowledge--Instructional units or items that have little or no bearing on the job responsibilities of their technicians.

Eighty-six percent of the forms sent to industry were returned. The total number of electronic technicians employed by the 175 responding firms supplying this employment data was 15,828, and the range of employment was from 1 to 5,463.

The purpose of the information obtained through these checklist forms was to make a comparative analysis of the electronic content taught in public post-high school technical institutes and knowledge requirements of electronic technicians. The analysis was performed by assigning relative values to the instructional units according to the distribution of responses to each of the 435 units in question.

As a result of the analysis, the instructional units were placed in four separate tables as follows:

Industrially Required and Taught in Depth.

Industrially Preferred but Taught in Depth.

Industrially Preferred and Discussed Briefly.

Industrially Unnecessary but Discussed Briefly.

Of the 435 units of content analyzed, 72.6 percent were taught in depth and 27.4 percent were discussed briefly. Industrially, 20.5 percent of the content was required knowledge; 77 percent was preferred knowledge; and 2.5 percent was unnecessary knowledge. There was educational and industrial agreement on the amount of emphasis placed on 45.3 percent of the electronic content. In the remaining 54.7 percent of the instructional units, educators placed more emphasis on content than industrial personnel believed necessary.

Conclusions

The total analysis revealed that electronic instructors placed significantly more emphasis on basic electronic content than industrial personnel indicated was necessary. Specifically, the following conclusions were reached:

1. Eighty-nine instructional units were placed in the category of industrially required and taught in depth, and 108 content units were designated as industrially preferred and discussed briefly. In these instances, the hypothesis that no major differences existed between electronic course content offered in technical institutes and subject matter required of electronic technicians was accepted.

2. A total of 227 instructional units were represented in the category, industrially preferred but taught in depth. An additional 11 units of instruction were designated as industrially unnecessary but discussed briefly. Here, the hypothesis was rejected because more educational emphasis was placed on content than industrial personnel indicated was necessary. Either the instructors were justified in over-emphasizing these units to compensate for lack of knowledge retention, or better utilization of additional time spent on these units should have been considered.

The foregoing conclusions were obtained from the analysis performed on the data collected for this research.

The following generalizations resulted from the synthesis of opinions expressed by educational and industrial personnel participating in this investigation.

1. Some technical supervisors expressed the need for specialized electronic training for their technicians. However, the consensus was that the post-high school institutes provided their technical students with more than the basic requirements necessary to enter into the labor market as a first-level technician. Industrial personnel believed that they themselves could best provide the technician with the specific training needed for the development of a high level of proficiency in the product produced or service rendered.

2. Technical instructors reported that they could place twice as many technicians as they graduated. They believed that coordinated guidance activities and increased instruction time in the two-year curriculum would result in a lower dropout rate and in the placement of more electronic technicians.

3. The positions which could be filled by electronic technicians covered the entire spectrum from routine jobs to those that required a high degree of specialization. Therefore, a customized approach to technical training ranging from one to three years would reduce the dropout rate, encourage more students to enter the technical field, and better meet the demands of industry whose technical needs range from the relatively simple to the most complex.

Recommendations

In light of the analysis made and of the reactions obtained from industrial and educational personnel, the following recommendations are presented:

1. A study should be made to ascertain the feasibility of developing a continuous technical curriculum whereby a student could enter a technical program and progress according to his ability. The type of employment he could demand would depend upon the level of proficiency he obtained upon terminating his formal education.

2. To coordinate this educational approach, a closer working relationship between guidance, industrial,

and educational personnel is recommended. More emphasis should be placed upon the development and use of curriculum guides designed to implement this diversified approach to technical training.

3. Similar research should be conducted in other regions to ascertain the extent to which post-high school technical programs, through electronic content offerings, are meeting industry's needs.

4. Regional content studies in other technologies such as mechanical, civil, and drafting should be initiated.

5. A follow-up study of electronic technology graduates should be conducted to determine the extent to which the technical curriculum they pursued is meeting their vocational needs.

It is believed that these findings will provide a sound basis for adjustments in the electronic curriculums and result in updated programs attuned to industrial needs.

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APPENDIX A

INFORMATION FORM IV (EDUCATIONAL)

BASIC ELECTRONIC KNOWLEDGE REQUIREMENTS OF ELECTRONIC TECHNICIANS

Mississippi State University State College, Mississippi

INFORMATION FORM IV (EDUCATIONAL)
BASIC ELECTRONIC KNOWLEDGE REQUIREMENTS OF ELECTRONIC TECHNICIANS

INSTRUCTIONAL UNITS OR ITEMS	Taught in Depth	Discussed Briefly	Not Taught
DIRECT CURRENT			
Basic Principles	---	---	---
electrical resistance, voltage and current			
batteries			
magnetic fundamentals			
series, parallel, and combination circuit theory			
D-C circuit applications			
troubleshooting D-C circuits			
electro-capacitance			
Network Laws (A-C and/or D-C)	---	---	---
Ohm's law			
Kirchhoff's laws			
power formulas			
Thevenin's theorem			
Norton's theorem			
Millman's theorem			
the superposition theorem			
maximum-power transfer theorem			
(others)			
ALTERNATING CURRENT			
Basic Principles	---	---	---
electromagnetism			
magnitude of induced voltage			
sine waves			
electromotive force			
Vectors and Phase Relationship	---	---	---
vectors and vector diagrams			
instantaneous values			
phase relationships			
complex numbers (J number)			
polar vectors			
Transformers	---	---	---
theory			
turns ratio			
impedance matching			
transformer losses and ratios			
types and applications (general)			
delta and wye			
three-phase			
frequency response			
(others)			

INSTRUCTIONAL UNITS OR ITEMS	Taught in Depth	Discussed Briefly	Not Taught
TEST EQUIPMENT			
Meter and Generator Usage	---	---	---
basic meter movements			
VTVM			
multimeters			
ohmmeters			
oscilloscope			
wavemeters			
impedance bridge			
A-C bridge			
thermocouple meter			
wattmeter			
tube testers			
transistor analyzers			
capacitor tester			
Q meter			
frequency meter			
sine-wave generator			
signal generator			
pulse generator			
square wave generator			
sweep frequency generator			
linearity generator			
color-bar generator			
stroboscope			
(others)			
INDUCTANCE AND CAPACITANCE			
Inductance	---	---	---
self-inductance			
mutual inductance			
series and parallel			
Lenz's law			
L-R circuits and time constants			
inductive reactance			
lag angle			
effects of varying circuit properties			
instantaneous current analysis			
a-f and r-f chokes			
Q of a coil			
frequency response			
high-frequency coils			
low-frequency coils			

INSTRUCTIONAL UNITS OR ITEMS	Taught in Depth	Discussed Briefly	Not Taught
Capacitance	----	----	----
theory of operation			
capacitor types and rating			
effects in D-C circuits			
R-C circuits and time constants			
capacitive reactance			
lead angle			
effects of varying circuit properties			
bypass capacitor effect			
R-L-C Circuits	----	----	----
series R-L-C circuits			
parallel R-L-C circuits			
Parallel, Series Resonant Circuits	----	----	----
resonant circuit "Q"			
analysis of series and parallel resonant circuits			
applications of resonant circuits			
resonant circuit bandwidth			
resonance curves			
resonant filters			
(others)			
VACUUM TUBES			
Fundamentals	----	----	----
early development and use			
emitter materials			
types of envelopes and bases			
types of emission			
cathods; directly and indirectly heated			
filaments, methods of heating			
Diodes	----	----	----
characteristic curves			
rectification, detection			
Triodes	----	----	----
biasing methods, positive and negative			
load lines			
saturation			
interelectrode capacitance			
transconductance, plate resistance			
static and dynamic characteristic curves			
transfer curves			
amplification factor			
voltage amplification			
equivalent circuits			
Tetrodes	----	----	----
interelectrode capacitance			
effect of screen grid			
effects of secondary emission			
plate and screen characteristic curves			
Pentodes	----	----	----
effect of suppressor grid			
plate and dynamic characteristic curves			
tube parameters			
sharp and remote cutoff characteristics			
Multigrid Tubes	----	----	----
frequency conversion			
pentagrid convertors			
pentagrid mixers			
beam power tubes			
multisection tubes			
Special Application Tubes	----	----	----
subminiature tubes			
gas-filled regulators			
thyratron tubes			
ignitrons			
phototubes			
photo-multiplier tubes			
electron-ray indicators			
cathode-ray tubes			
high frequency tubes			
klystrons			
(others)			
SEMICONDUCTORS			
Fundamentals	----	----	----
early development and use			
atomic structure			
crystal structure			
bonds			
impurities			
classification			
electrons and hole charges			
Semiconductor Diodes	----	----	----
color code			
PN junctions			
forward and reverse bias			
characteristic curves			
point-contact diodes			
tunnel diodes			
zener diodes			
silicon controlled rectifiers and switches			
variable-capacitance diodes			
photodiodes and photo transistors			
hall generators			
(others)			
TRANSISTORS			
Construction and Characteristics	----	----	----
point contact transistor			
junction type transistors			
gain			
transistor fabrication			
static characteristic curves			
dynamic transfer curves			
transistor biasing			
physical circuit operation (NPN and PNP)			
load lines			

INSTRUCTIONAL UNITS OR ITEMS	Taught in Depth	Discussed Briefly	Not Taught
graphical analysis			
thermal properties			
operating point			
transistor noise			
hybrid parameters			
Special Purpose Transistors	---	---	---
tetrode transistors			
photosensitive transistors			
power transistors			
unijunction transistors			
field-effect transistors			
thyristors			
microcircuits			
(others)			

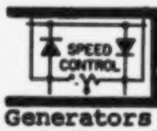
BASIC CIRCUITS AND SYSTEMS

INSTRUCTIONAL UNITS OR ITEMS	Taught in Depth	Discussed Briefly	Not Taught
Power Supplies	---	---	---
methods of rectification			
types of rectifier circuits			
principles of filtering			
voltage dividers and doublers			
polyphase power supplies			
r-f power supplies			
voltage-regulator circuits			
power supply troubles			
Amplifier Fundamentals	---	---	---
classes of operation			
decibels			
stereophonic sound			
D-C amplifier gain			
A-C amplifier gain			
frequency response			
Basic Vacuum Tube Amplifiers and Circuits	---	---	---
a-f amplifiers			
paraphase amplifiers			
cathode follower			
i-f amplifier			
push-pull amplifier			
amplifier coupling			
audio preamplifier circuits			
audio-output stage			
tone control circuits			
bandpass amplifier circuits			
attenuators			
delayed-action circuits			
coupling			
mixing circuits			
Loudspeakers	---	---	---
headsets			
dynamic speakers			
electrostatic speakers			
P-M speakers			
speaker enclosures			
Microphones and Pickups	---	---	---
carbon			
capacitor			
crystal			
dynamic			
velocity			
ceramic			

INSTRUCTIONAL UNITS OR ITEMS	Taught in Depth	Discussed Briefly	Not Taught
Oscillators	---	---	---
feedback-degeneration and regeneration			
phase-shift oscillators			
tuned plate-grid oscillators			
Hartley oscillators			
Colpitts oscillators			
Armstrong oscillators			
electron-coupled oscillators			
Pierce-oscillators			
crystal overtone oscillators			
R-F Amplifiers and Circuits	---	---	---
r-f amplifier circuits (general)			
r-f power amplifiers			
wide-band amplifiers			
single and double tuned circuits			
neutralizing circuits			
r-f buffer and frequency multiplying			
troubleshooting procedures			
Transmitter Fundamentals	---	---	---
c-w transmitter keying			
classification of wave emission			
parasitics and harmonics			
percentage of modulation			
plate and grid modulation			
power distribution in a-m wave			
transmitter measurements			
a-m, f-m comparisons			
transmitter alignment			
Radio Transmitters and Circuits	---	---	---
c-w transmitters			
v-h-f transmitters			
u-h-f transmitters			
a-m transmitters and circuits			
sideband transmitters			
f-m (reactance-tube) transmitters			
f-m (phase) transmitters			
troubleshooting procedures			
Transmission of Radio Waves	---	---	---
principles of radiation			
radio-wave propagation			
antenna fundamentals			
transmission line theory			
types of antennas			
FCC regulations			
Radio Receiver Fundamentals	---	---	---
reading schematic diagrams			
hetrodyning principles			
a-m detection			
f-m detection			
alignment procedures			
troubleshooting procedures			
Radio Receivers and Circuits	---	---	---
T-R-F receivers			
superhet. receivers (general)			
am-fm receivers			
sideband receivers			
special receiver circuits			
AVC circuits			

INSTRUCTIONAL UNITS OR ITEMS	Taught in Depth	Discussed Briefly	Not Taught
the B+ supply			
squelch circuits			
limiters			
discriminators			
(others)			
TRANSISTOR CIRCUITS			
Transistor Amplifier Fundamentals	----	----	----
reading transistor specs.			
classes of operation			
current, voltage, and power gain			
base, emitter phase relationships			
input and output resistance			
volume and tone controls			
effects of feedback			
equivalent circuits			
transistor measurements			
troubleshooting procedures			
Transistor Amplifiers and Circuits	----	----	----
common emitter, collector and base configurations			
push-pull amplifiers			
cascade audio amplifiers			
R-C coupled audio amplifiers			
direct-coupled amplifiers			
power amplifiers			
tuned amplifiers			
reflex amplifiers			
D-C amplifiers			
magnetic amplifiers			
low-frequency amplifiers			
high-frequency amplifiers			
r-f and i-f amplifiers			
wide-band amplifiers			
preamplifiers			
phase inverters			
bridge arrangements			
symmetry circuits			
transistor current regulators			
transistor voltage regulators			
bias circuits			
stabilized circuits			
printed circuits			
Transistor Receivers	----	----	----
power supplies			
oscillators			
modulation, mixing, and detection circuits			
agc circuits			
(others)			
ADVANCED CIRCUITS AND SYSTEMS			
Nonsinusoidal Waveshapes	----	----	----
square waves			
rectangular waves			
sawtooth waves			
triangular and peaked waves			
multi-segmented waves			
curved wave forms			
transients			
D-C components of waveforms			
A-C components of waveforms			
waveform generation			
Pulse and Switching Circuits	----	----	----
diode and triode switching circuits			
free running multivibrators			
bistable multivibrators			
monostable multivibrators			
astable multivibrators			
blocking oscillators			
shock-excited oscillators			
gas-tube relaxation oscillators			
gating circuits			
delay circuits			
saturable-core reactor circuits			
pulse generators			
triggering circuits			
pulse counters			
logic circuits			
pulse amplifiers			
linear wave shaping			
binary systems			
decimal systems			
null detectors			
Digital Computer Fundamentals	----	----	----
computer applications			
computer programming			
computer math			
adders and subtractors			
methods of data storage			
analog-to-digital conversion			
Limiters, Clampers, Counters	----	----	----
diode limiters			
triode limiters			
diode clamping			
counters (frequency divider)			
diode clippers			
Sweep-Generator Circuits	----	----	----
sawtooth-wave form circuits			
gas-tube sweep generator circuits			
vacuum-tube sweep-generator circuits			
transistor sweep-generator circuits			
sweep expansion and delay circuits			
TV Transmitters and Receivers	----	----	----
frequency bands			
standard interlaced scanning			
composite TV picture signal			
camera tubes			
TV image and image resolution			
TV transmitter functional analysis			

INSTRUCTIONAL UNITS OR ITEMS	Taught in Depth	Discussed Briefly	Not Taught
TV receiver functional analysis			
(others)			
TRANSMITTER MICROWAVE ELECTRONICS			
Microwave Transmission	---	---	---
communications transmitters			
radar transmitters			
generating microwave signals			
cavity resonators			
waveguides			
duplexers			
microwave antennas			
transmission lines			
wavelength measurement			
Special Amplifiers	---	---	---
grounded-grid amplifiers			
vidio amplifiers			
D-C amplifiers			
traveling-wave amplifiers			
parametric amplifiers			
masers			
lasers			
Miscellaneous (microwave)	---	---	---
backward-wave oscillators			
microwave mixers			
using Smith chart			
Microwave Receivers	---	---	---
communications receiver			
radar receiver			
Multiplexing	---	---	---
time-division multiplexing principles			
time-division multiplex transmitter and receiver analysis			
frequency-division multiplexing principles			
frequency-division multiplex transmitter and receiver analysis			
Microwave Measurements	---	---	---
attenuation measurements			
power measurements			
reflectometer measurements			
frequency measurements			
phase-shift measurements			
measurement of Q			
noise measurements			
dielectric measurements			
impedance measurements			
directional couplers			
absorption wavemeter			
VSWR measurements			
coaxial-cable measurements			
propagation patterns			
Radar System Principles	---	---	---
block diagram analysis			
CRT types			
Radar sweep chains			
range-mark generator chains			
delay devices in radar systems			

INSTRUCTIONAL UNITS OR ITEMS	Taught in Depth	Discussed Briefly	Not Taught
radar modulators			
magnetrons			
Navigational Electronics	---	---	---
sonar			
loop antennas			
radio detection finders			
loran			
(others)			
 INDUSTRIAL ELECTRONICS			
Generators and Motors (Types and Theory)	---	---	---
A-C and D-C generators			
A-C and D-C motors			
single-phase principles			
three-phase principles			
converters, inverters, and dynamotors			
generator and motor maintenance			
speed regulators			
automatic motor controls			
Synchros and Control Systems	---	---	---
synchro applications			
synchro principles			
differential synchro			
synchro control transformer			
geared synchro systems			
synchro capacitors			
synchro connections			
Servo Control Devices and Systems	---	---	---
fundamental servo principles			
common servomechanism systems			
servomechanism chains			
frequency response of servo systems			
Industrial Electronic Applications and Devices	---	---	---
Decision or intelligence devices			
electronic control systems			
simple electronic circuits			
ultrasonics			
electronic heating and welding			
transducers			
thermistors			
temperature recorders			
varistors			
time-delay relays			
large-current polyphase rectifiers			
high frequency wavelengths			
high-speed light and register controls			
thyratron controls			
electronic timer circuits			
radiation inspection and detection			
photoelectric devices			

Comments:

Name

Address

City State

Experience in Electronics:

Teaching ______________ years Industry ______________ years

Military ______________ years Other ______________ years

Please return the completed form to:

R. J. Vasek
Drawer NU
Mississippi State University
State College, Mississippi 39762

APPENDIX B

INFORMATION FORM V (INDUSTRIAL)

BASIC ELECTRONIC KNOWLEDGE REQUIREMENTS OF ELECTRONIC TECHNICIANS

Mississippi State University State College, Mississippi

INFORMATION FORM V (INDUSTRIAL)
BASIC ELECTRONIC KNOWLEDGE REQUIREMENTS
OF ELECTRONIC TECHNICIANS

INSTRUCTIONAL UNITS OR ITEMS	Required Knowledge	Preferred Knowledge	Unnecessary Knowledge
DIRECT CURRENT			
Basic Principles	---	---	---
electrical resistance, voltage and current			
batteries			
magnetic fundamentals			
series, parallel, and combination circuit theory			
D-C circuit applications			
troubleshooting D-C circuits			
electro-capacitance			
Network Laws (A-C and/or D-C)	---	---	---
Ohm's law			
Kirchhoff's laws			
power formulas			
Thevenin's theorem			
Norton's theorem			
Millman's theorem			
the superposition theorem			
maximum-power transfer theorem			
(others)			
ALTERNATING CURRENT			
Basic Principles	---	---	---
electromagnetism			
magnitude of induced voltage			
sine waves			
electromotive force			
Vectors and Phase Relationship	---	---	---
vectors and vector diagrams			
instantaneous values			
phase relationships			
complex numbers (J number)			
polar vectors			
Transformers	---	---	---
theory			
turns ratio			
impedance matching			
transformer losses and ratios			
types and applications (general)			
delta and wye			
three-phase			
frequency response			
(others)			

INSTRUCTIONAL UNITS OR ITEMS	Required Knowledge	Preferred Knowledge	Unnecessary Knowledge
TEST EQUIPMENT			
Meter and Generator Usage	---	---	---
basic meter movements			
VTVM			
multimeters			
ohmmeters			
oscilloscope			
wavemeters			
impedance bridge			
A-C bridge			
thermocouple meter			
wattmeter			
tube testers			
transistor analyzers			
capacitor tester			
Q meter			
frequency meter			
sine-wave generator			
signal generator			
pulse generator			
square wave generator			
sweep frequency generator			
linearity generator			
color-bar generator			
stroboscope			
(others)			
INDUCTANCE AND CAPACITANCE			
Inductance	---	---	---
self-inductance			
mutual inductance			
series and parallel			
Lenz's law			
L-R circuits and time constants			
inductive reactance			
lag angle			
effects of varying circuit properties			
instantaneous current analysis			
a-f and r-f chokes			
Q of a coil			
frequency response			
high-frequency coils			
low-frequency coils			

INSTRUCTIONAL UNITS OR ITEMS	Required Knowledge	Preferred Knowledge	Unnecessary Knowledge
Capacitance	----	----	----
theory of operation			
capacitor types and rating			
effects in D-C circuits			
R-C circuits and time constants			
capacitive reactance			
lead angle			
effects of varying circuit properties			
bypass capacitor effect			
R-L-C Circuits	----	----	----
series R-L-C circuits			
parallel R-L-C circuits			
Parallel, Series Resonant Circuits	----	----	----
resonant circuit "Q"			
analysis of series and parallel resonant circuits			
applications of resonant circuits			
resonant circuit bandwidth			
resonance curves			
resonant filters			
(others)			
VACUUM TUBES			
Fundamentals	----	----	----
early development and use			
emitter materials			
types of envelopes and bases			
types of emission			
cathods; directly and indirectly heated			
filaments, methods of heating			
Diodes	----	----	----
characteristic curves			
rectification, detection			
Triodes	----	----	----
biasing methods, positive and negative			
load lines			
saturation			
interelectrode capacitance			
transconductance, plate resistance			
static and dynamic characteristic curves			
transfer curves			
amplification factor			
voltage amplification			
equivalent circuits			
Tetrodes	----	----	----
interelectrode capacitance			
effect of screen grid			
effects of secondary emission			
plate and screen characteristic curves			
Pentodes	----	----	----
effect of suppressor grid			
plate and dynamic characteristic curves			
tube parameters			
sharp and remote cutoff characteristics			
Multigrid Tubes	----	----	----
frequency conversion			
pentagrid convertors			
pentagrid mixers			
beam power tubes			
multisection tubes			
Special Application Tubes	----	----	----
subminiature tubes			
gas-filled regulators			
thyratron tubes			
ignitrons			
phototubes			
photo-multiplier tubes			
electron-ray indicators			
cathode-ray tubes			
high frequency tubes			
klystrons			
(others)			
SEMICONDUCTORS			
Fundamentals	----	----	----
early development and use			
atomic structure			
crystal structure			
bonds			
impurities			
classification			
electrons and hole charges			
Semiconductor Diodes	----	----	----
color code			
PN junctions			
forward and reverse bias			
characteristic curves			
point-contact diodes			
tunnel diodes			
zener diodes			
silicon controlled rectifiers and switches			
variable-capacitance diodes			
photodiodes and photo transistors			
hall generators			
(others)			
TRANSISTORS			
Construction and Characteristics	----	----	----
point contact transistor			
junction type transistors			
gain			
transistor fabrication			
static characteristic curves			
dynamic transfer curves			
transistor biasing			
physical circuit operation (NPN and PNP)			
load lines			

INSTRUCTIONAL UNITS OR ITEMS	Required Knowledge	Preferred Knowledge	Unnecessary Knowledge
graphical analysis			
thermal properties			
operating point			
transistor noise			
hybrid parameters			
Special Purpose Transistors	---	---	---
tetrode transistors			
photosensitive transistors			
power transistors			
unijunction transistors			
field-effect transistors			
thyristors			
microcircuits			
(others)			
BASIC CIRCUITS AND SYSTEMS			
Power Supplies	---	---	---
methods of rectification			
types of rectifier circuits			
principles of filtering			
voltage dividers and doublers			
polyphase power supplies			
r-f power supplies			
voltage-regulator circuits			
power supply troubles			
Amplifier Fundamentals	---	---	---
classes of operation			
decibels			
stereophonic sound			
D-C amplifier gain			
A-C amplifier gain			
frequency response			
Basic Vacuum Tube Amplifiers and Circuits	---	---	---
a-f amplifiers			
paraphase amplifiers			
cathode follower			
i-f amplifier			
push-pull amplifier			
amplifier coupling			
audio preamplifier circuits			
audio-output stage			
tone control circuits			
bandpass amplifier circuits			
attenuators			
delayed-action circuits			
coupling			
mixing circuits			
Loudspeakers	---	---	---
headsets			
dynamic speakers			
electrostatic speakers			
P-M speakers			
speaker enclosures			
Microphones and Pickups	---	---	---
carbon			
capacitor			
crystal			
dynamic			
velocity			
ceramic			

INSTRUCTIONAL UNITS OR ITEMS	Required Knowledge	Preferred Knowledge	Unnecessary Knowledge
Oscillators	---	---	---
feedback-degeneration and regeneration			
phase-shift oscillators			
tuned plate-grid oscillators			
Hartley oscillators			
Colpitts oscillators			
Armstrong oscillators			
electron-coupled oscillators			
Pierce-oscillators			
crystal overtone oscillators			
R-F Amplifiers and Circuits	---	---	---
r-f amplifier circuits (general)			
r-f power amplifiers			
wide-band amplifiers			
single and double tuned circuits			
neutralizing circuits			
r-f buffer and frequency multiplying			
troubleshooting procedures			
Transmitter Fundamentals	---	---	---
c-w transmitter keying			
classification of wave emission			
parasitics and harmonics			
percentage of modulation			
plate and grid modulation			
power distribution in a-m wave			
transmitter measurements			
a-m, f-m comparisons			
transmitter alignment			
Radio Transmitters and Circuits	---	---	---
c-w transmitters			
v-h-f transmitters			
u-h-f transmitters			
a-m transmitters and circuits			
sideband transmitters			
f-m (reactance-tube) transmitters			
f-m (phase) transmitters			
troubleshooting procedures			
Transmission of Radio Waves	---	---	---
principles of radiation			
radio-wave propagation			
antenna fundamentals			
transmission line theory			
types of antennas			
FCC regulations			
Radio Receiver Fundamentals	---	---	---
reading schematic diagrams			
hetrodyning principles			
a-m detection			
f-m detection			
alignment procedures			
troubleshooting procedures			
Radio Receivers and Circuits	---	---	---
T-R-F receivers			
superhet. receivers (general)			
am-fm receivers			
sideband receivers			
special receiver circuits			
AVC circuits			

INSTRUCTIONAL UNITS OR ITEMS	Required Knowledge	Preferred Knowledge	Unnecessary Knowledge
the B+ supply			
squelch circuits			
limiters			
discriminators			
(others)			
TRANSISTOR CIRCUITS			
Transistor Amplifier Fundamentals	----	----	----
reading transistor specs.			
classes of operation			
current, voltage, and power gain			
base, emitter phase relationships			
input and output resistance			
volume and tone controls			
effects of feedback			
equivalent circuits			
transistor measurements			
troubleshooting procedures			
Transistor Amplifiers and Circuits	----	----	----
common emitter, collector and base configurations			
push-pull amplifiers			
cascade audio amplifiers			
R-C coupled audio amplifiers			
direct-coupled amplifiers			
power amplifiers			
tuned amplifiers			
reflex amplifiers			
D-C amplifiers			
magnetic amplifiers			
low-frequency amplifiers			
high-frequency amplifiers			
r-f and i-f amplifiers			
wide-band amplifiers			
preamplifiers			
phase inverters			
bridge arrangements			
symmetry circuits			
transistor current regulators			
transistor voltage regulators			
bias circuits			
stabilized circuits			
printed circuits			
Transistor Receivers	----	----	----
power supplies			
oscillators			
modulation, mixing, and detection circuits			
agc circuits			
(others)			
ADVANCED CIRCUITS AND SYSTEMS			
Nonsinusoidal Waveshapes	----	----	----
square waves			
rectangular waves			

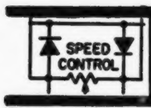
INSTRUCTIONAL UNITS OR ITEMS	Required Knowledge	Preferred Knowledge	Unnecessary Knowledge
sawtooth waves			
triangular and peaked waves			
multi-segmented waves			
curved wave forms			
transients			
D-C components of waveforms			
A-C components of waveforms			
waveform generation			
Pulse and Switching Circuits	----	----	----
diode and triode switching circuits			
free running multivibrators			
bistable multivibrators			
monostable multivibrators			
astable multivibrators			
blocking oscillators			
shock-excited oscillators			
gas-tube relaxation oscillators			
gating circuits			
delay circuits			
saturable-core reactor circuits			
pulse generators			
triggering circuits			
pulse counters			
logic circuits			
pulse amplifiers			
linear wave shaping			
binary systems			
decimal systems			
null detectors			
Digital Computer Fundamentals	----	----	----
computer applications			
computer programming			
computer math			
adders and subtractors			
methods of data storage			
analog-to-digital conversion			
Limiters, Clampers, Counters	----	----	----
diode limiters			
triode limiters			
diode clamping			
counters (frequency divider)			
diode clippers			
Sweep-Generator Circuits	----	----	----
sawtooth-wave form circuits			
gas-tube sweep generator circuits			
vacuum-tube sweep-generator circuits			
transistor sweep-generator circuits			
sweep expansion and delay circuits			
TV Transmitters and Receivers	----	----	----
frequency bands			
standard interlaced scanning			
composite TV picture signal			
camera tubes			
TV image and image resolution			
TV transmitter functional analysis			

INSTRUCTIONAL UNITS OR ITEMS	Required Knowledge	Preferred Knowledge	Unnecessary Knowledge
TV receiver functional analysis			
(others)			

TRANSMITTER

MICROWAVE ELECTRONICS

INSTRUCTIONAL UNITS OR ITEMS	Required Knowledge	Preferred Knowledge	Unnecessary Knowledge
Microwave Transmission	---	---	---
communications transmitters			
radar transmitters			
generating microwave signals			
cavity resonators			
wavequides			
duplexers			
microwave antennas			
transmission lines			
wavelength measurement			
Special Amplifiers	---	---	---
grounded-grid amplifiers			
vidio amplifiers			
D-C amplifiers			
traveling-wave amplifiers			
parametric amplifiers			
masers			
lasers			
Miscellaneous (microwave)	---	---	---
backward-wave oscillators			
microwave mixers			
using Smith chart			
Microwave Receivers	---	---	---
communications receiver			
radar receiver			
Multiplexing	---	---	---
time-division multiplexing principles			
time-division multiplex transmitter and receiver analysis			
frequency-division multiplexing principles			
frequency-division multiplex transmitter and receiver analysis			
Microwave Measurements	---	---	---
attenuation measurements			
power measurements			
reflectometer measurements			
frequency measurements			
phase-shift measurements			
measurement of Q			
noise measurements			
dielectric measurements			
impedance measurements			
directional couplers			
absorption wavemeter			
VSWR measurements			
coaxial-cable measurements			
propagation patterns			
Radar System Principles	---	---	---
block diagram analysis			
CRT types			
Radar sweep chains			
range-mark generator chains			
delay devices in radar systems			
radar modulators			
magnetrons			
Navigational Electronics	---	---	---
sonar			
loop antennas			
radio detection finders			
loran			
(others)			



INDUSTRIAL ELECTRONICS

INSTRUCTIONAL UNITS OR ITEMS	Required Knowledge	Preferred Knowledge	Unnecessary Knowledge
Generators and Motors (Types and Theory)	---	---	---
A-C and D-C generators			
A-C and D-C motors			
single-phase principles			
three-phase principles			
converters, inverters, and dynamotors			
generator and motor maintenance			
speed regulators			
automatic motor controls			
Synchros and Control Systems	---	---	---
synchro applications			
synchro principles			
differential synchro			
synchro control transformer			
geared synchro systems			
synchro capacitors			
synchro connections			
Servo Control Devices and Systems	---	---	---
fundamental servo principles			
common servomechanism systems			
servomechanism chains			
frequency response of servo systems			
Industrial Electronic Applications and Devices	---	---	---
Decision or intelligence devices			
electronic control systems			
simple electronic circuits			
ultrasonics			
electronic heating and welding			
transducers			
thermistors			
temperature recorders			
varistors			
time-delay relays			
large-current polyphase rectifiers			
high frequency wavelengths			
high-speed light and register controls			
thyratron controls			
electronic timer circuits			
radiation inspection and detection			
photoelectric devices			

Comments:

____

____

____

____

____
Name

____
Address

______________________ ______________________
City State

Experience in Electronics:

Teaching ______________ years Industry ______________ years

Military ______________ years Other ______________ years

Please return the completed form to:

R. J. Vasek
Drawer NU
Mississippi State University
State College, Mississippi 39762